

THE EAST AFRICAN AGRICULTURAL JOURNAL

of
KENYA
TANGANYIKA
UGANDA AND
ZANZIBAR

•
Vol. XVII—No. 2

OCTOBER
1951

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Price
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IN THIS ISSUE:

NOTES ON LINING EARTH CHANNELS

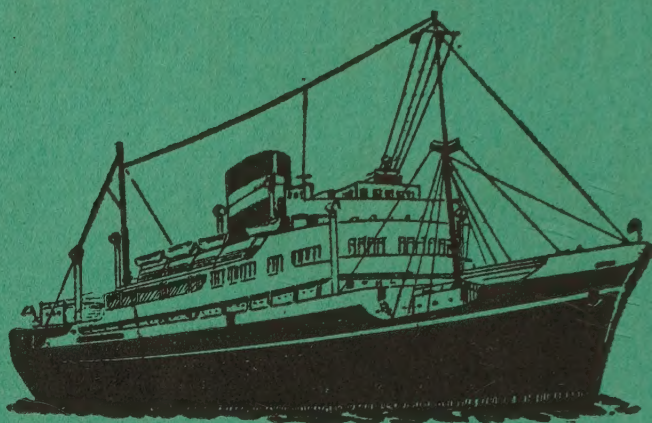
THE UBIQUITOUS TERMITE

SOME OBSERVATIONS ON AFRICAN
HORSE-SICKNESS

NOTES ON ANIMAL DISEASES—II

BEEKEEPING OBSERVATIONS IN TANGA-
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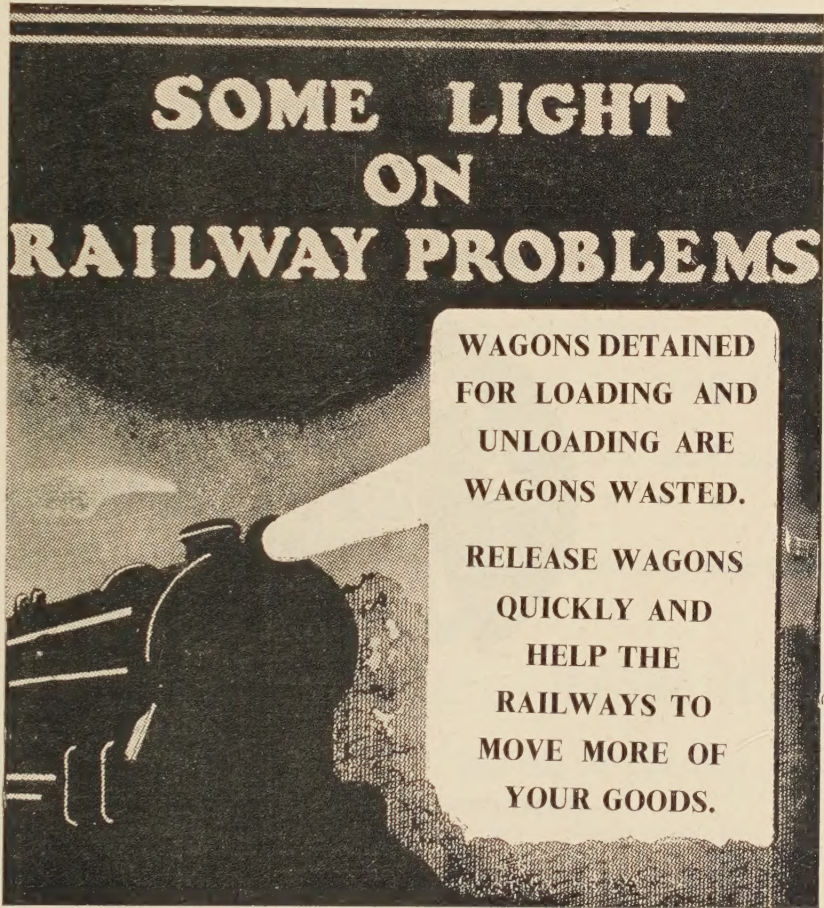
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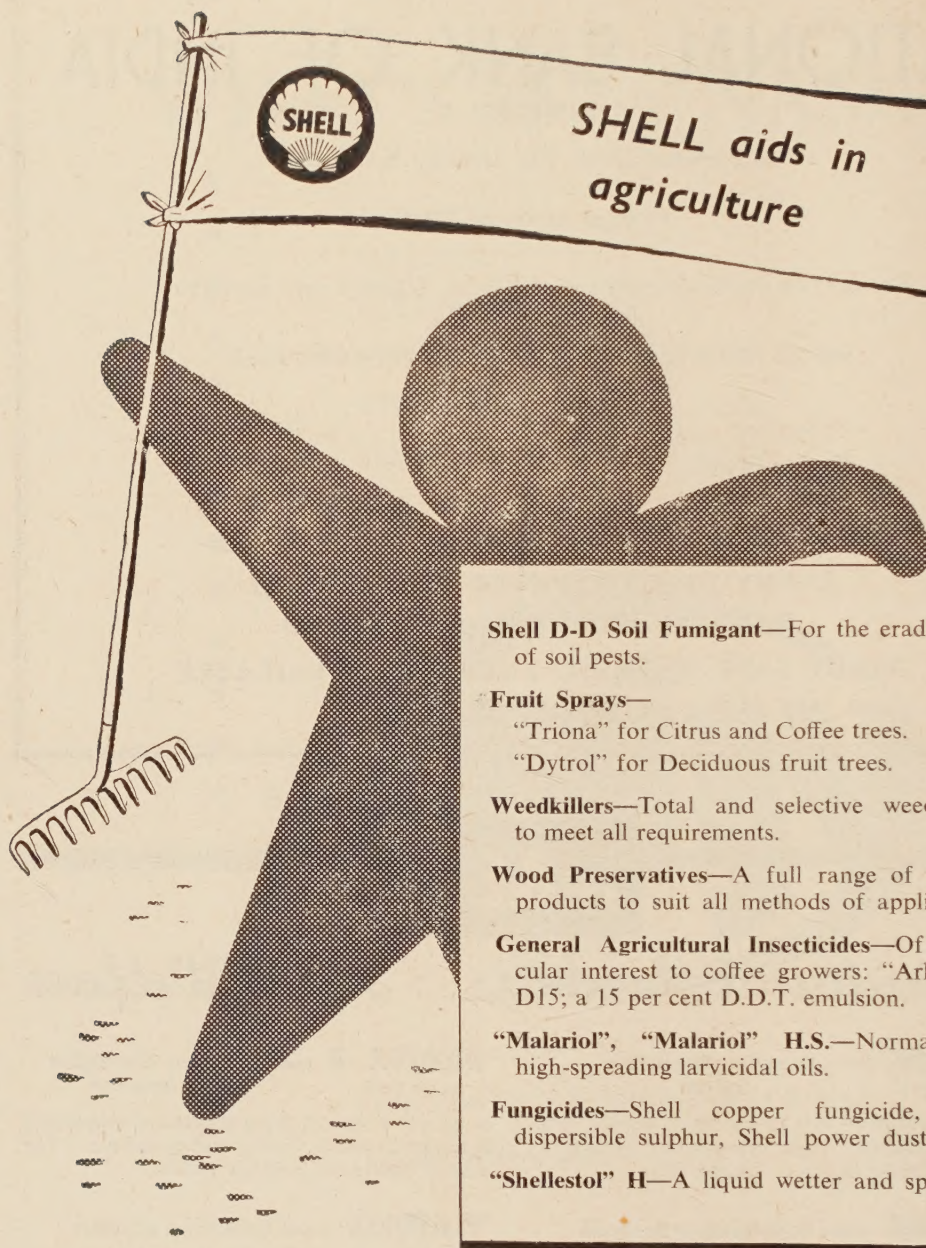
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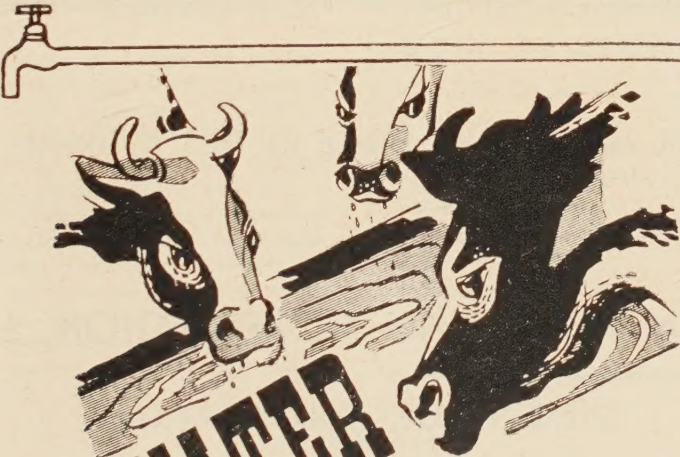
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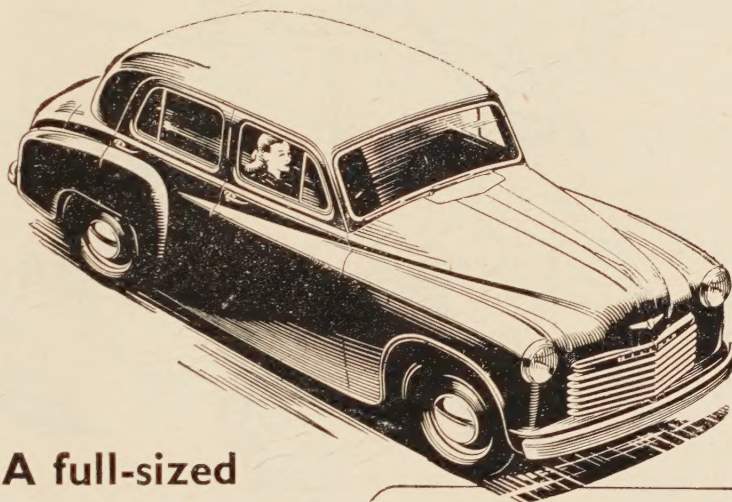
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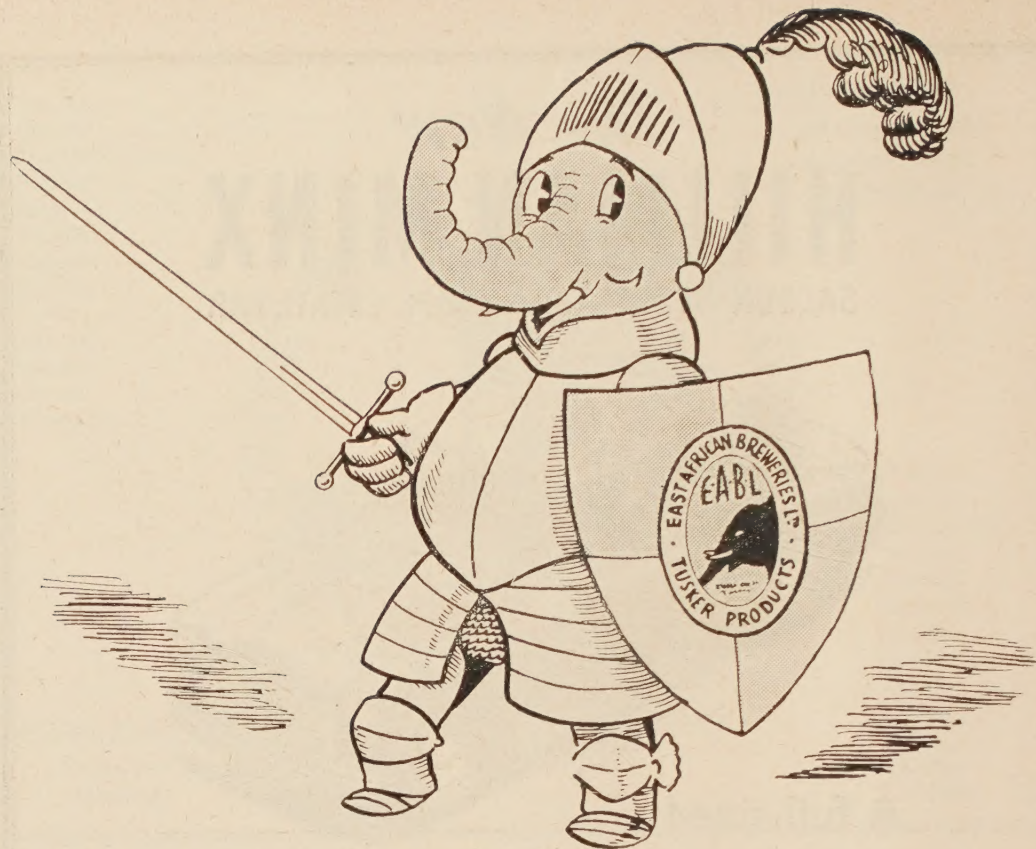
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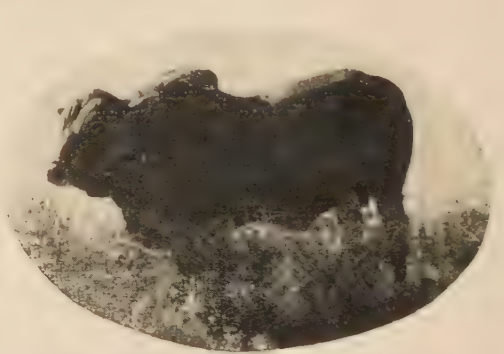
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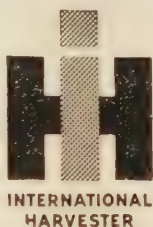
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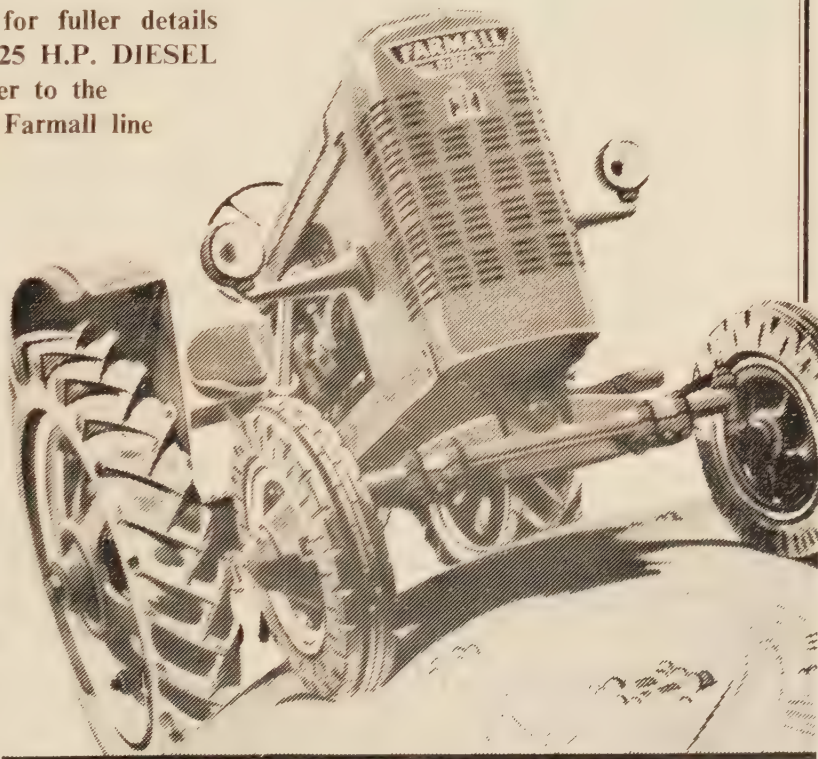
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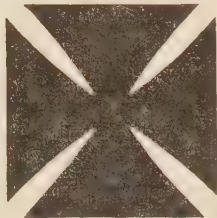


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Printed and published by the Government Printer, Nairobi.

*Issued under the Authority of the East Africa High Commission and published every three months—
July, October, January, April. Volume consists of four issues (commencing July issue).*

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

CONTENTS

	PAGE		PAGE
The Broadening Outlook	51	The Amount of Milk Consumed by Suckling Calves from Birth to Weaning	80
Notes on Lining Earth Channels	53	A Note on the Measurement of Rainfall Intensity	82
The Ubiquitous Termite	60	Beekeeping Observations in Tanganyika, 1950/51	84
Some Observations on African Horse-sickness	62	A Note on the Release of some New Cereal Varieties—III	88
Notes on Animal Diseases—II	65	Graphical Field Keys of Uganda Trees—I ..	90
Observations on the Chafer Grub	69		

INDEX TO ADVERTISERS

	PAGE		PAGE
A. Baumann & Co., Ltd.	XVI	East African Railways and Harbours ..	I
African Explosives & Chemical Industries (E.A.), Ltd.	XVII & XIX	Gailey & Roberts, Ltd.	X
African Mercantile Co., Ltd.	XIII	Howse & McGeorge, Ltd.	XIV
Arthur A. White, Ltd.	XIII	International Harvester Co. of E.A., Ltd. ..	XV
Barclays Bank (D.C. & O.)	V	Kenya Advertising Corporation, Ltd.	VI
Beales & Co., Ltd.	IX	May & Baker Co. (E.A.), Ltd.	III
Bovill, Matheson & Co., Ltd.	XI	National Bank of India, Ltd.	III
British East Africa Corporation, Ltd. ..	XX	Ndurumo, Ltd.	XII
Caltex (Africa), Ltd.	COVER PAGE 3	R. E. Smith, McCrae, Johnson & Co., Ltd. ..	II
Craelius East African Drilling Co., Ltd. ..	V	Shell Chemicals, Ltd.	IV
Devonshire Motors, Ltd.	VII	Shell Co. of E.A., Ltd.	XVIII
Dunlop Tyres	COVER PAGE 4	Smith, Mackenzie & Co., Ltd.	COVER PAGE 2
East African Breweries, Ltd.	VIII	South British Insurance Co., Ltd.	XVI
		Standard Bank of South Africa, Ltd. ..	VI

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		*Horticultural Abstracts	35

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Bulletin 39.—Five Hundred Varieties of Herbage and Fodder Crops. Price Sh. 15, March, 1948.

This work brings together in the first place information received from specialists in many parts of the world on crop varieties used in the feeding of farm stock. The notes have been made to give, in as concise a form as possible, the necessary details regarding origin, adaptation, characteristics, and use of the strains in various countries, together with possibilities of obtaining supplies. Secondly, the index has been designed to supplement the first part and contains references to published information on crop varieties compiled over a period of 17 years in the Commonwealth Bureau located at Aberystwyth.

The information, which is collated in this way for the first time, will reveal not only the need for a completion of the data by the inclusion of entries from other countries, but also the desirability of some attempt being made by research workers to achieve uniformity in regard to standards, nomenclature, synonyms, etc.

COMMONWEALTH BUREAU OF HORTICULTURE AND PLANTATION CROPS, EAST MALLING

Technical Communication No. 17.—Chemical Composition of Plants as an Index to their Nutritional Status, by D. W. Goodall and F. G. Gregory. A Review of 165 pages with 900 references to literature. July, 1947. Price Sh. 9.

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THE BROADENING OUTLOOK

Forestry is a long-term job and still very primitive in most parts of the world. Apart from the older European countries and India, scientific forestry has only been in existence for some 50 years. In East Africa the period is even shorter. It therefore behoves all countries, territories, colonies, dominions, etc., to get together and pool their experience, so that mistakes may not be repeated.

It is good to learn that towards the end of last year an International Mission of Tropical Foresters went to the United States of America for a two months' tour. This visit was organized by the Technical Assistance Division of the Organization for European Economic Co-operation, and was the first tour organized for overseas members of the European nations. Forty-one foresters, English, French, Belgian and Dutch from all over the world gathered in Washington last October, East Africa being represented by two Silviculturists (from the East African Agricultural and Forestry Research Organization and Tanganyika) and two Sawmillers (from Kenya and Uganda).

On arrival they were divided into three teams and toured separately for two months in different parts of the U.S.A. to study logging, sawmilling and seasoning (Team 1), marketing (Team 2), and technical forestry, reafforestation, forest research and soil erosion (Team 3). Their report* has just been issued in Paris and makes interesting reading. The teams saw most of the U.S.A. from east to west, and from north to south, and when they gathered again in Washington at the end of November to produce a combined report, it was realized how valuable their experience had been. It may seem strange for East African foresters to go to the U.S.A. but it must be remembered that here we are anxious to sell our hardwoods abroad, and we are busy planting softwoods, many of which came originally from the Southern States. The sawmillers saw modern machinery and methods, and the foresters saw the pines and cypresses in their own home. The foresters also studied such pertinent subjects as erosion control, catchment area management, and research on the water

requirements of vegetation, all of which are controversial subjects in East Africa, and on which we require more experience and more facts.

It is difficult to pick out particular points from such a comprehensive report which covers the whole of forestry not only as a natural asset and a sound business, but also as a technical profession. Some of the lessons learned are, however, of special importance to East Africa. For instance, the first recommendation records: "To enable present inaccessible forests to be used and also to reduce the cost of production in lands already being worked, Governments are urged to give their immediate and vigorous attention to the improvement and enlargement of roads, railways, waterways, harbours, telephones, telegraph, etc.". How very pertinent this is in East Africa!

The sawmillers and loggers were impressed by modern machinery and methods of using it, and recommended that there should be a dollar allocation for its purchase. Let us hope they get it, for lack of such machinery here is holding up not only forest production, but farm production and improvement of communications.

All teams were literally staggered by the work out-turn of labour, both African and American. A recommendation of the mission records: "One of the most impressive observations made on the tour was the high standard of efficiency of skilled and semi-skilled labour. In centres where facilities do not already exist, it is recommended that trade schools be provided for practical technical education of indigenous people". The team saw one sawmill in particular worked by African labour, which was very comparable in size of the mill and the material they were cutting to some East African sawmills. The output per man-hour of this African labour was actually worked out and found to be very many times the output per man-hour of an East African sawmill.

The forestry team saw a nursery which was producing pine seedlings for planting. It was run by six men, three of whom were skilled and also did the machine maintenance; and

* O.E.E.C. Tropical Timber Mission. T.A.D. 18/A. Final Report, Paris, 1951 (English and French), pp. (I) 1-126 and (II) 1-83.

three were unskilled. In addition, they had the help of 40 coloured women for one month. This labour force raises 10,000,000 trees per year at a total cost of \$2.25 per 1,000 (about Sh. 13/6 per 1,000). In other words, while American labour is on the job, it works!

Another lesson East Africa could well take note of is that of pasture improvement combined with erosion control. On real "bad lands" that have been very seriously eroded and overgrazed, erosion control and improvement of pastures costs money, and in East Africa is often not undertaken on this account. Many examples were seen where money spent on such works was a paying proposition after a number of years and this, too, without taking account of the rehabilitation of thousands of acres of the countryside and its people.

The forestry team had another illuminating experience, and that was to find that in many places forests were valued more for their water than for their timber. This water was valued not only for its quantity but its quality. One pulp wood factory was dependent for its water supplies on a catchment that carried material suitable for the pulp mill. The working of the mill was dependent on the minimum hot weather water supply, and actually paid the watershed owners so much per acre per year *not* to exploit the forest on it. Further than that, they realized that a fire meant serious erosion and a dirty water supply for some time, so in addition they paid the watershed owners so much per acre per year for successful fire protection.

America has been forced to mechanization by the high cost of labour in spite of the high

output per man-hour. Here we may be forced to mechanization in many places by shortage of labour. Examples were seen where plants were raised entirely mechanically in the nursery, and even planted in the field mechanically, scarcely having been touched by hand since the seed came off the trees. The great surprise to the mission, however, was that these machines were rarely due to big engineering brains sitting down and designing them. They were usually originated by a semi-skilled hand devising a simple machine to save himself trouble, and to get more production and more wages. Such machines were copied and improved by his friends and so spread until finally an engineering firm added the finishing touches, and put it into mass production.

One could comment at great length on this interesting 209-page report, but the above should be sufficient to give a general idea of its possible benefits to East Africa.

The importance of such tours as described in the report cannot be over emphasized. East Africa tends to be very parochial in its outlook, not only between territories, but even between districts in the same territory. The more we can get around and see and benefit by what our neighbours are doing, the more likely we are to raise the standard of production and living of our own region. We cannot be too grateful to the U.S.A. for their foresight and generosity in arranging this visit, and hope that in the near future we can reciprocate.

A.L.G.

NOTES ON LINING EARTH CHANNELS

Compiled by the Hydraulic Branch, Public Works Department, Kenya

(Received for publication on 16th August, 1951)

The following notes are intended for the guidance of non-technical persons desirous of lining water furrows to prevent leakage and erosion and to reduce the work and cost of maintenance. The method chosen will, of course, depend upon availability and cost of the materials; the work can be carried out by semi-skilled and unskilled labour with reasonable supervision.

PRELIMINARY WORK

Before lining the channel, it should be neatly shaped and formed to a uniform grade or series of uniform grades. Any hollows or irregularities should be filled in with moist soil and rammed to shape. It is important that the bed of the channel be firm before lining is placed. The uniformity of gradient can be checked simply by the use of three sight sticks or "boning rods" as they are sometimes called. The sight sticks are best made in the shape of the letter T, the upright being about three feet and the horizontal piece about 12 inches long; the three T's should be exactly the same height and the cross piece must form a true right angle with the vertical piece.

In order to obtain an even grade (or slope) between any two points of the furrows, a sight stick should be held upright at each of two selected points on grade with its lower end resting on the bed of the furrow; the third sight stick being held in a similar manner at any intermediate point at which it is desired to check the grade. An observer standing a yard or so behind the first stick and sighting over the three T's can readily see whether they are on the same line of sight; should the middle sight stick be below the line of sight it will

indicate a hollow at that point, on the other hand if the middle sight stick shows above the line of sight it will indicate that it is on a high point.

In preparing the furrow allowance must be made for the thickness of the lining. (See Fig. 1.)

After working the bottom of the channel to a uniform gradient or series of gradients the sides should be trimmed to proper shape. The actual shape will depend on the type of lining to be employed. In some kinds of lining it will be possible and even easier to fill back behind the sides of the lining with dry soil and ram it solid. It will be readily seen which kinds of lining can be "back-filled".

TYPES OF LINING

The following methods of lining will be explained:—

1. Dressed stone masonry.
2. Precast concrete channels.
3. Cast *in situ* concrete.
4. Stone pitching.
5. Clay puddle.

When deciding upon the method to be used, the size of furrows necessary to carry the required amount of water must also be considered. Diagrams I and II will assist in the choice of a suitable size of channel. The method of using these diagrams is described below. The first three methods described will provide a fairly smooth-surfaced furrow in which water will flow a great deal faster than in an earth furrow; in fact the discharge would be about twice that of the average earth furrow of equal size and depth of water.

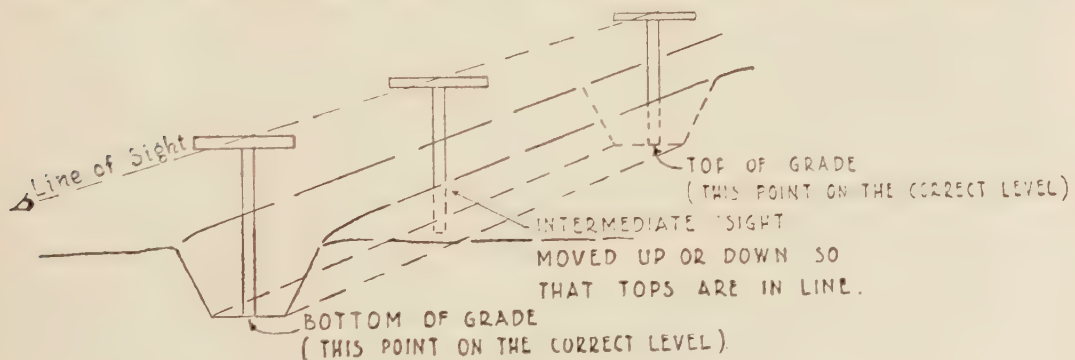


FIG. 1

CAPACITY OF CONCRETE FURROWS FOR VARIOUS GRADES

Diagram 1

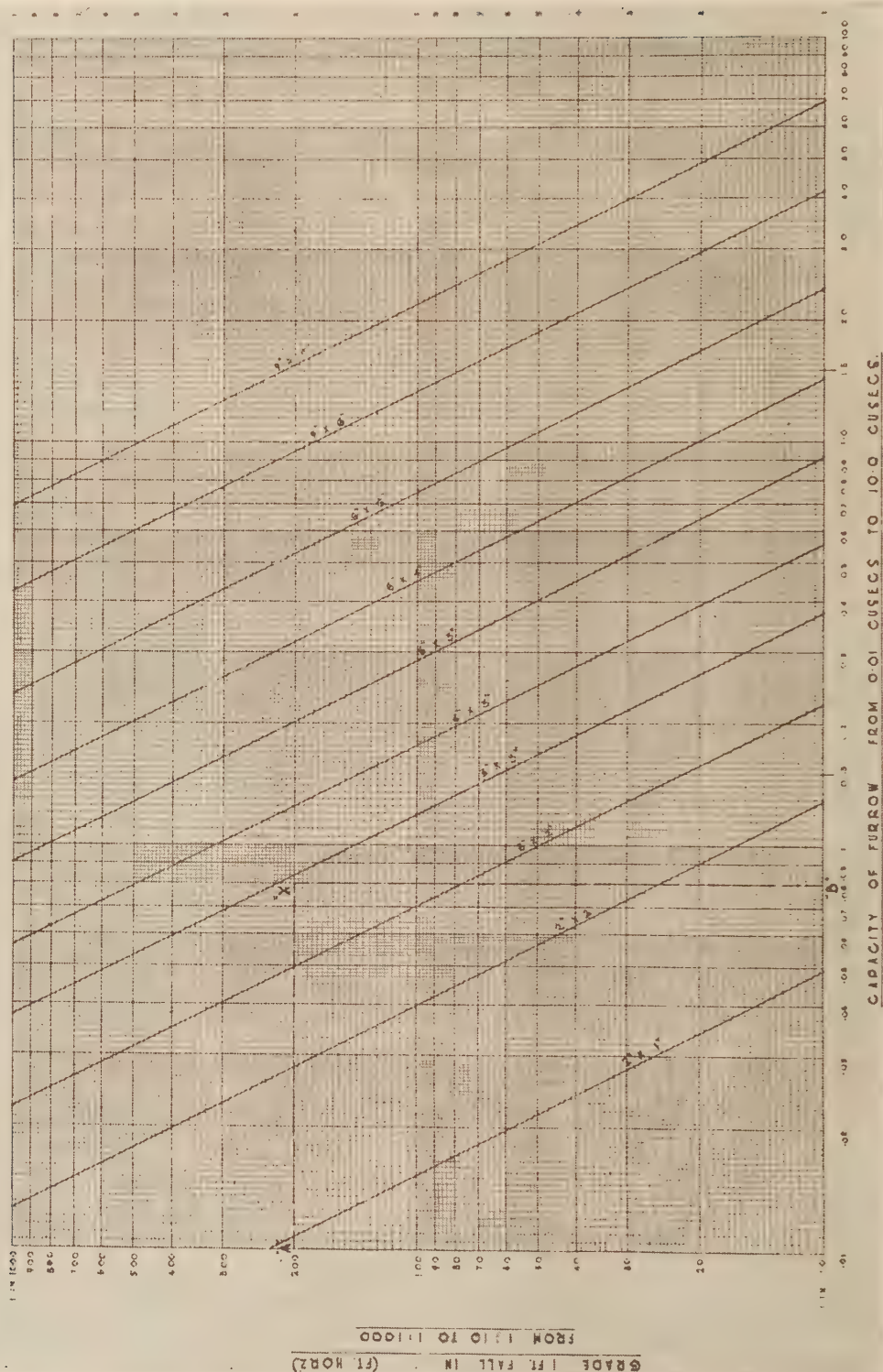
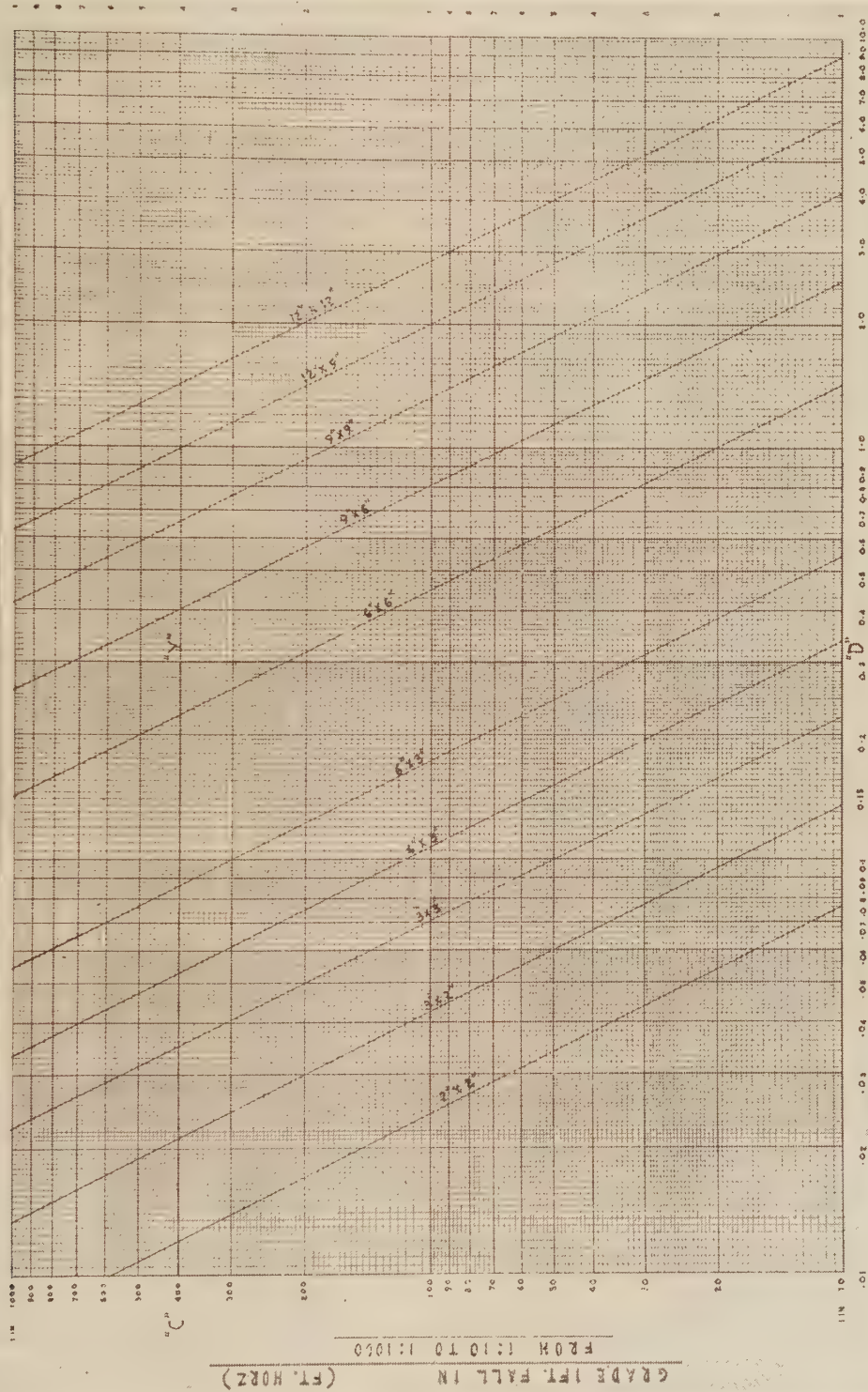


Diagram 2

CAPACITY OF MASONRY FURROWS FOR VARIOUS GRADES.



CAPACITY OF FURROW FROM 0.01 CUSECS TO 10.0 CUSECS.

The lining must extend sufficiently far up the sides of the furrow to ensure that water will not overflow the lining and saturate the earth behind. Should there be a change of slope in the furrow from a fairly steep to a flatter grade, it may be necessary to provide an overflow at the point, or increase the size of the furrow.

Method of Using Diagrams I and II

Two charts are given—one to be used when concrete is the chosen material and the other for masonry. The diagonals give the size required for any given grade and discharge. The sizes given represent the area of *waterway* required and a suitable amount must be added to the depth of the finished channel to allow for freeboard (i.e. the clearance from the water surface to the edge of the channel). The amount will vary with the size of the channel and the depth of water and the following may be used as a guide:—

Depth of Water	Freeboard
2"–5"	2"
6"–10"	3"
12"–15"	4"
Over 15"	6"

Example 1

Grade: 1 in 200.
Discharge: 0.08 Cusecs.
Material: Concrete.

From the point 200 (point "A") on the "gradient" scale draw a line at right angles. From the point 0.08 on the "Discharge" scale (point "B") draw a line at right angles. The two lines meet at "X". The nearest diagonal line *to the right* of this point is marked 3" x 3" = 9 square inches. This is the size of waterway required, and the size of the finished channel should be three inches wide at the bed, and five inches deep (allowing three inches water depth and, say, two inches freeboard).

Example 2

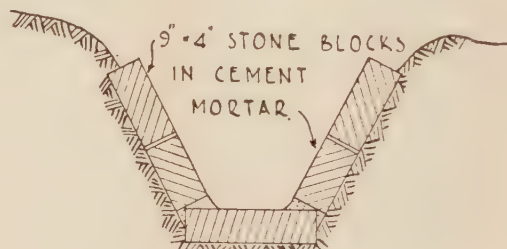
Grade: 1 in 400.
Discharge: 0.3 Cusecs.
Material: Masonry.

From the point 400 on the gradient scale (point "C") draw a line at right angles. From the point 0.3 on the Discharge scale (point "D") draw a line at right angles. The two lines meet at "Y". The nearest

diagonal line *to the right* (the next largest size) is marked 9" by 6". This is the waterway required and the size of the furrow should be 9" wide at the bed and 9" deep (allowing 3" freeboard).

Dressed Stone Masonry.—In districts where building stone is available this may be the easiest form of lining to construct, 9" x 4" stone would be suitable.

The sides and bottom of the earth furrow should be trimmed to the desired shape; the stone blocks should then be placed carefully into position, if necessary being bedded on to a little loose earth or sand. The stones should be jointed in cement mortar of not less than one part cement to four parts of clean sand, care being taken to see that there is a good mortar joint between the stones forming the bottom of the furrow and the sides, as shown in Fig. 2.



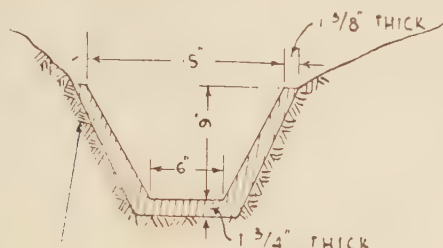
IF BURNT BRICKS ARE READILY AVAILABLE, A BRICK LINED FURROW CAN BE CONSTRUCTED IN A SIMILAR MANNER

FIG. 2

Precast Concrete Channels.—A suitable size and shape of precast concrete channel to carry about one cubic foot of water per second is as shown in Fig. 3. A convenient length of such a channel section is two feet. The sections can be laid in the earth furrow after the base of the furrow has been smoothed to a uniform grade and the butting ends "battered" with cement mortar made of three parts of fine clean sand and one part of cement. The precast sections cost about Sh. 1/50 per foot length at the concrete works. Larger sections are obtainable for carrying a larger flow, for example 24" wide by 9" deep cost about Sh. 2/80 per foot.

A similar process is to use half-round channels which are half sections of concrete pipes. Eighteen-inch diameter channels would be suitable and cost about Sh. 2/50 per foot

length at works. It may be found, however, that these are more difficult to lay than the angular channel.



GROUND BEHIND SIDES
OF CONCRETE CHANNEL
TO BE FILLED BACK
AND CONSOLIDATED

FIG. 3

If these kinds of channel lining are used the ground should be filled back behind the sides and consolidated unless it is an entirely new furrow which can be cut to proper shape before lining. Any other form of half pipe could, of course, be used and the method is similar.

The concrete sections can be cast on or near the site. Several "forms" or moulds should be made—and the concrete poured into the mould when it is placed upside down relative to its position in the finished channel. The concrete would best be made of four parts of $\frac{1}{2}$ " stone, two parts of sand and one part of cement and well rammed into the mould.

RECTANGULAR CHANNELS

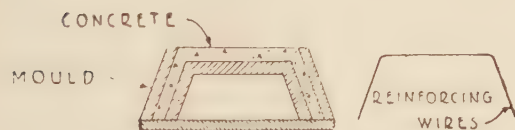
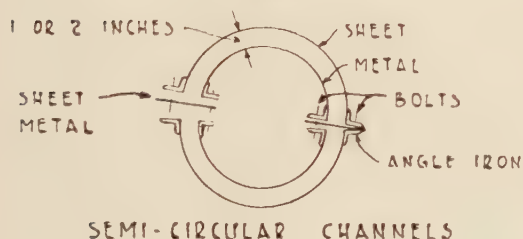


FIG. 4



SEMI-CIRCULAR CHANNELS

LENGTH OF FORM ABOUT
2 OR 3 FEET PLACED ON
END FOR POURING CONCRETE

FIG. 5

Reinforcing rods should be used; No. 8 galvanized wire is suitable. These should be cut and bent as shown in Fig. 5, and placed in the mould six inches apart, before the concrete is poured. The rods should be finally positioned as the concrete is being placed in the moulds, care being taken to see that the wires lie in the middle of the thickness of the concrete.

The quantities of materials required for these shapes are as follows:—

(a) 6" wide by 9" deep open box channel as described above.

Per 100-foot length:

Cement: 630 lb.

Dry sand: 20 cubic feet.

Stone: 40 cubic feet. (Four parts not larger than $\frac{3}{4}$ " plus two parts not larger than $\frac{1}{2}$ ", or a mixture approximating to that).

Water: 30 gallons.

(b) 9" diameter half-round channel (half pipes).

Per 100-foot length:

Cement: 150 lb.

Dry sand: 5 cubic feet.

Stone: 10 cubic feet.

Water: 8 gallons.

(c) 12" diameter half-round channel.

Per 100-foot length:

Cement: 210 lb.

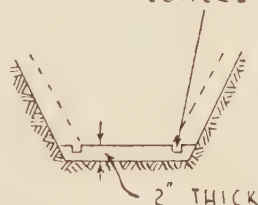
Dry sand: 7 cubic feet.

Stone: 14 cubic feet.

Water: 10 gallons.

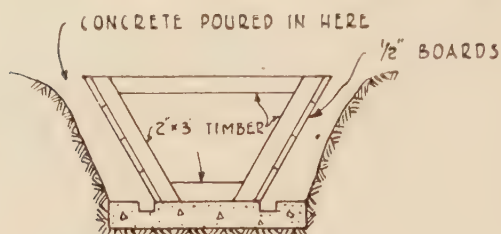
Cast in situ Lining.—The shape of this type of lining would be the same as in a precast lining. In this method a form, somewhat longer than the precast mould, should be made, six feet long would probably be convenient. It would be made in the shape of the sides only. The floor of the channel would first be cast thus:—

KEY MADE WITH A STRIP
OF WOOD ABOUT $\frac{3}{4}$ "
 $\frac{3}{4}$ " - REMOVED WHEN
CONCRETE IS SET



FIRST STAGE: CONCRETE BED

FIG. 6A



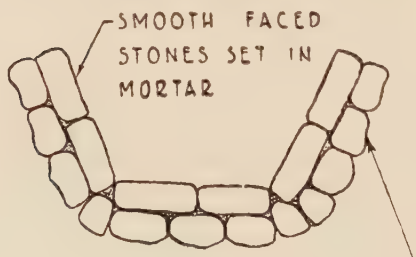
SECOND STAGE . CONCRETE SIDES

FIG. 6B

After the floor has set hard the form would be placed over it and the two sides concreted. A temporary end to the form is necessary to retain the concrete when wet. If it is required to do the work more speedily, several forms should be used and laid end to end. Forms can be made of either hard timber or sheet metal. Timber moulds should be greased with old sump oil or other similar lubricant on the faces in contact with the concrete.

Stone Pitching.—If suitable good-shaped flat stones are easily obtainable, a stone-pitched channel would be suitable. The stones should be fairly smooth on one face at least, and could be of any size from, say, 6" to 18" largest dimensions. Those to be used on the inside faces of the channel should be fairly hard and non-abrasive.

The construction should be thus:—



LESS REGULAR STONES
MAY BE USED AT THE
BACK

FIG. 7



FIG. 8

The furrow should first be dressed to the approximate shape of the outside of the lining,

any spaces behind it being subsequently filled in with earth and consolidated. A pair of templates should be used, one at the beginning and one at the end of the section under construction. (See Fig. 8.) They should be set with the help of sighting rods. Strings should then be stretched between them at each inside corner corresponding to the final shape of the channel and the lining then built out to the string. The stones should be set in cement mortar, a weaker mortar can be used at the back of the lining.

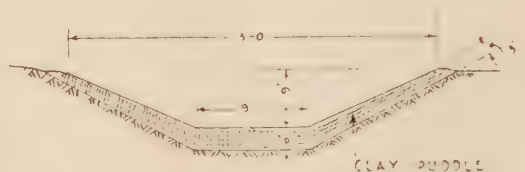


FIG. 9

Clay Puddle.—If suitable clay is available, a fairly water-tight lining can be made with it. (See Fig. 9.) The obvious disadvantages, however, are that it is not permanent, requires much maintenance and is vulnerable to damage by stock. Only good clay should be used. If broken apart while dry, the fracture should not show a crystalline appearance, and it should feel definitely oily between the fingers when wet. A reliable test is to make the clay into a ball about three inches in diameter and immerse in water. A good clay should not fall apart within 48 hours. Another test is to moisten the clay and roll it between the palms of the hands to form a "string". If it is not possible to form an unbroken string at least three inches long and about one-eighth of an inch thick, the clay is not suitable.

After the clay is dug out, it should be spread out and left exposed to the open air for about 24 hours in layers of not more than 12 inches thick, before puddling. Puddling consists of working with water until it becomes a homogeneous plastic mass and is best done in a pit, being worked with boys' feet. The puddle is ready when a roll about one inch diameter and 12 inches long will not break if held up by one end, the other end hanging free.

Lay the puddled clay in the furrow in layers about three inches thick and smooth to shape with trowel or spade. It should be noted that if the furrow is left dry for more than a couple of days the clay will dry out and crack and will not readily regain its impermeability.

SUMMARY OF THE TYPES OF LINING DESCRIBED

<i>Type of Lining</i>	<i>Possible Advantages</i>	<i>Disadvantages</i>
Precast concrete box channels.	With care a permanent job is obtained. Simple to carry out. Easy to clean and clear. Can be cast at site with a certain amount of skilful supervision of unskilled labour. Various sizes are obtainable.	Expensive, if precast units have to be transported or if concrete materials have to be transported.
Half-round channels of concrete or other form of piping.	As for box channels except that moulds would be more difficult to make locally. Ordinary clay half-round pipes may be more readily obtainable.	Expensive, if precast units have to be transported or if concrete materials have to be transported.
Concrete lining cast <i>in situ</i> .	A permanent job. Easy to clear and clean.	Rather more skill required. Materials may be expensive if transport required.
Stone pitching. Dressed stone masonry.	Stone may be readily obtainable. Simple to carry out with practice. Easy to maintain. A fairly permanent job.	Little or no disadvantage if transport of material is not a serious matter.
Clay puddle.	If suitable clay is obtainable adjacent to the site of work, the cost should be low. Simple to construct, if care is taken with levels.	If channel dries out, clay will crack. Subject to damage by cattle. Will require repair from time to time.

THE UBIQUITOUS TERMITE*

By W. V. Harris, Termite Research Unit, E.A. Agriculture and Forestry Research Organization

I have always thought that the poet Wordsworth was rather unfair to the angler whose primrose by the river's brim was just a primrose. To appreciate a thing you must have some interest in or knowledge of it, and most of us are limited in our capacity for interest or knowledge. No doubt the angler's wife knew all about *Primula vulgaris* and spent hours each Spring admiring it.

It is much the same with most people when it comes to termites. Beyond their nuisance value they arouse little comment in East Africa—"eaten by white ants" is a verdict like the coroner's "death by misadventure", a matter for regret, of course, but unavoidable—and yet there are in Kenya, Uganda and Tanganyika more different varieties of termites than there are of a well-known brand of preserved foods. One or two kinds attract attention by the mounds they build, large mounds of red earth or those numberless little grey hummocks found in seasonal swamps and mountain grasslands. But most of them are inconspicuous soil-dwellers, or borers in the dead branches of trees, depending for survival on their ability to hide from their enemies. The soil-dwelling termites are practically everywhere in East Africa, apart from sand dunes, swamps, salt pans and ground over seven or eight thousand feet above sea level; and it is because they are everywhere in the soil, on which we depend for food and on which we build, that it is important for us to be quite clear how they stand in relation to us, how much they compete, and how much they co-operate.

It is essential, at the outset, to realize how very different in their way of life are the different groups of termites. Early in the history of the earth, soon after the primitive insects were getting used to having wings, an ancestor of the cockroaches developed a new technique for feeding. By itself this roach was unable to digest cellulose, and so it had to look for wood that had begun to rot or had been invaded by fungi. Then somehow—we do not know exactly when or how—it began to give shelter in its gut to small microscopic animals called protozoa which could break down cellulose, and thus was able to bore into sound wood and live on that; it simply carried on with the digestion of the particles where the protozoa left off. At the same time as it was boring to obtain food, the roach was obtaining shelter

from its enemies. The first termites evolved from this kind of roach and they kept this wood-boring habit and co-operation with protozoa. To ensure that her young were provided with the all-essential organisms, the mother termite stayed around when the young hatched out from their eggs and fed them with food containing the protozoa. This habit developed into the parents and their children remaining together until the children were fully grown, in fact they became a family. From this simple beginning has developed the intricate social life of the termites of to-day. Even now there are not many insects who have progressed so far; most of them do no more than lay their eggs in situations that give the newcomers a fair chance to find a meal before they die of starvation.

The next step was to have some of the young stop their development before they grew wings and became mature insects. Instead they grew large heads with stout sharp jaws and became soldiers whose purpose was to protect the family from its enemies. At the same time the chores in the colony were taken over entirely by the young and the parent termites left free to their egg-laying. With slight modifications, these termites have remained up to the present day. They are called the dry-wood termites. They bore in fallen trees, dead stumps, wounds and dry branches on living trees and in the woodwork of buildings. As they can withstand a certain amount of cold, they are to be found as far north as Bordeaux in Europe, the United States-Canadian border on the west coast of North America and high in the Himalayas, as well as throughout the tropics. When man began to build houses of wood he simply provided the dry-wood termites with the equivalent of many dead logs and branches to feed on. At the same time, by clearing away the natural forest he drove the termites into his houses. Fortunately the dry-wood termites in East Africa have shown considerable reluctance in attacking buildings, and only one native species is at present recorded as a pest. In old buildings at Dar es Salaam, ceiling boards and window frames are infested, though it is usually called "dry-rot". I expect similar damage is done to buildings at other towns on the coast as I have found this termite in a wild state in a number of places there. Dry-wood termites

* Text of a talk given on 17th June, 1951, in the General Overseas Service of the British Broadcasting Corporation.

are most common and most injurious to buildings in America, and already some American species have been introduced to other parts of the world.

As a further development, some termites began to live in the soil at the foot of trees and to build small tunnels up the trunks through which they could pass in safety in search of food. More of the young termites ceased their development before reaching the stage of growing wings, and another group or caste was developed to do the work of the colony. As these termites were now able to search widely for food, protected by their covered ways and by the active soldiers, they began to feed more and more on rotten wood and wood that had first been partially broken down by fungi. This made them less dependent on the intestinal protozoa, though the damp-wood termites to-day still maintain a certain number. These damp-wood termites have developed furthest in the Far East and Australia. The East African representatives are few, though there is one species which attacks buildings at the coast—also regarded by many people as dry rot.

The final development was for termites to dispense entirely with intestinal protozoa. They learnt to use their now complex social organization to provide a food supply of cellulose that had been partially broken down into a state suited to the termites' digestive powers. Practically all digestion is done by the workers, who provide food secretions for the rest of the colony—royal pair, soldiers and young. As well as wood damaged by fungus, these higher termites bring to the nest wood and woody material which they store until it has fermented, also they digest soil and remove the humus.

Such widely different food habits as we find in the dry-wood termites on the one hand and the ground-dwelling species on the other is of prime importance when methods of controlling injurious termites have to be considered. For instance, in East Africa where dry-wood termites so rarely occur in buildings, the whole question of preventing termite damage to our buildings is the simple one of providing a barrier which will prevent termites coming up into the building from the ground below. I say "simple" because it lacks all the complications which arise in other countries where dry-wood termites fly in at swarming time and start infestations in the roof or anywhere else they fancy. In East Africa the issue is straightforward. It is for the architect to design and for the builder to construct a termite-proof barrier

in each new building. It will, naturally, add to the initial cost of building, but what is that compared with the expense and irritation resulting from termite infestation later on? No scientific knowledge is necessary beyond that which is now available, the problem is one of building technique, plus a little bit of psychology about being penny wise and pound foolish.

The high degree of social organization achieved by the higher termites, especially those of Africa and Tropical Asia, is shown by the enormous number of individuals in some termite nests and by the size of the mounds they are able to construct. It is a far cry from the dry-wood termite society consisting of a female, a male, a dozen soldiers and from fifty to a hundred young stages, all living inside an inch or two of dead branch, to the hundreds of thousands of soldiers, workers, nymphs and the royal pair inhabiting one of those thirty-foot mounds not uncommon in a belt of country right across Africa from Ango'a to Tanganyika. The development which has made this organization possible is the construction of fungus gardens within the nest. Open up any large mound in East Africa, or dig down into one of those pieces of bare ground where a series of holes the size of a teacup shows that there is a subterranean nest. You will come across oval brown masses like coarse sponges filling many of the chambers. These masses are the fungus gardens. They are constructed by the worker termites from woody material of all kinds—vegetable debris, dead branches, newspaper, door frames, ceiling boards and clothing of vegetable origin—anything in fact they can lay their jaws on by burrowing underground, working on the surface of the ground or invading our homes. The woody material is chewed and mixed with saliva until it forms a malleable paste which is then moulded in position. The new comb quickly becomes carpeted with a fine layer of soft fungus threads. Later on there appear numerous white globes, the size of a pin-head, which are a simple type of fruiting body produced by the fungus, and which are eaten by the young termites. The fungus combs are used as nurseries, and cover a wide area owing to the honeycomb construction of the nest. As the eggs pour out of the queen in a continuous stream they are quickly removed by the workers to these nurseries and spread out over the combs, and there the delicate soft white larvæ emerge. Tended by worker-nurses these young termites remain in the fungus gardens until they are fully grown soldiers, workers or winged forms, capable of

withstanding the varying climate of the outer world. For the young termites are delicate creatures and it is only because these fungus gardens operate a kind of air-conditioning system that they are able to develop regularly. If you measure the temperature inside the cells of a termite mound you will find that it is constant and above the average for the surrounding soil whose temperature fluctuates with day and night. If you measure the humidity of the air inside the nest you will find it just a trifle below saturation. That the fungus comb can generate heat is easily demonstrated by sealing some of it up in a jar with a thermometer. Now if some accident to the outer walls of the mound caused the entrance of cooler air, the drop in temperature would cause the air within to lose moisture, and droplets of water would form in the nest, liable to drown the young termites. But the comb is so absorbent that it removes the surplus moisture before it ever forms drops, and returns it to the air again

when the humidity falls. Here we have an air-conditioning system which maintains a constant climate within the termite nest no matter whether the mound is in the moist heat of the coast, the dry desert-like heat of the Northern Frontier, among the cool banana gardens of Kilimanjaro, or withstanding the alternating floods and droughts of Nairobi. It used to be considered that man was the only animal that had achieved any manner of control over the climate by his methods of building houses and by the use of fire for heating, but it looks as though the termite got there first.

Any fool can destroy things, but it takes brains to build. So when we are dealing with termites, who may be destroying our timber-work and our crops, let us remember that they are also builders and as such are entitled to our respect. We cannot know too much about their ways if we are to compete with them successfully.

SOME OBSERVATIONS ON AFRICAN HORSE-SICKNESS INCLUDING AN ACCOUNT OF AN OUTBREAK AMONGST DOGS

By S. E. Piercy, Department of Veterinary Services, Kenya

(Received for publication on 30th July, 1951)

COLOSTRAL IMMUNITY AND THE IMMUNIZATION OF FOALS

The protection of adult equines against horse-sickness can readily be achieved by the intelligent use of neurotropic vaccine, obtained from the Onderstepoort Laboratories, South Africa, and issued by this department. This vaccine contains many different strains of virus attenuated by repeated passage through the brains of mice and it affords a wide cover of protection. Immunity takes some months to develop fully and horses should, therefore, be inoculated well in advance of the horse-sickness season. Acquired resistance tends to decrease after nine to ten months and it is recommended that horses should be re-inoculated annually. Animals that have been regularly vaccinated for several years become "salted" and acquire lasting immunity.

The successful immunization of foals presents a more complicated problem. This is because foals from susceptible dams gain no colostral immunity and are susceptible to infection at an early age. Such foals can be

successfully inoculated soon after birth. On the other hand, foals from immune dams, although susceptible when born, rapidly acquire adequate resistance through the colostrum. The protection thus gained remains significant for five to six months after which it gradually wanes. By seven to eight months old the foal becomes susceptible again and at this point should receive vaccine. If vaccinated earlier no extension of immunity will result.

However intelligently the immunization of foals is carried out, there may yet be an unavoidable period of some weeks when the animal is susceptible to natural infection. This is the period between the termination of colostral immunity and the commencement of significant acquired immunity following vaccination. The colostral immunity of foals will vary to some extent with the individual and, in the case of a foal in which it wanes rather sooner than the average, a susceptible period will occur. Should this gap between immunities coincide with the presence of natural infection,

the animal is likely to contract horse-sickness and die.

There would appear to be only one practicable method of overcoming this problem, namely, to breed from mares at a time which will ensure that foals are born about February or March in each year. They will then be at the height of their colostral immunity during the usual horse-sickness season of May and June.

A striking practical illustration of the precepts just outlined occurred recently when horse-sickness broke out in a stable in which were the following equines: three brood mares and seven other horses, all of which had been immunized four months previously; two non-vaccinated mares; and four foals aged about eight months. The dams of these foals had been vaccinated seven months prior to foaling. The foals were inoculated when four months old. The following events occurred: the two unvaccinated horses contracted horse-sickness and died. None of the immunized horses were affected, apart from the appearance of very mild symptoms in one. Three of the foals reacted and died. The fourth foal appeared to be unaffected.

Consideration of these results enables the following generalizations to be made:—

- (i) Uninoculated horses readily succumb in the presence of an outbreak and assist in the spread of the disease.
- (ii) Horses vaccinated some months prior to the appearance of infection are resistant and unlikely to experience anything more than the mildest of reactions.
- (iii) Foals whose colostral immunity has largely disappeared at the time of an outbreak are liable to contract horse-sickness and die.
- (iv) The inoculation of foals already possessing an appreciable colostral immunity is valueless, and indeed dangerous, in that a false sense of security may be engendered in the mind of the owner.
- (v) The immunity of foals should be renewed by vaccination towards the end of the period of colostral immunity.
- (vi) The danger period between colostral and vaccine immunities can best be offset by breeding at a time which will ensure that foals are at the height of their colostral immunity during the horse-sickness season.

AN OUTBREAK OF HORSE-SICKNESS IN DOGS

Following a number of deaths from horse-sickness, arrangements were made to salvage the horse meat by feeding it to a pack of hounds. Carcasses, which were dispatched immediately or soon after death, were received at the kennels concerned on 7th, 9th and 13th June, respectively. No cold storage facilities were available but the farm is situated at the high altitude of over 9,000 feet above sea level, and daily temperatures at the time alternated between 50° F. and 70° F. Owing to the accumulation of a large amount of horse meat the usual practice of cooking the dogs' food was not followed and the meat was fed raw.

Feeding commenced on 7th June, the day the first carcass was received. Ten days later one of the dogs was noticed to be seriously ill. The onset of sickness was sudden and was characterized by general malaise, inappetence, a high temperature (105° C.) and rapid, laboured breathing. Death occurred within 12 hours of the onset of symptoms. A post-mortem was performed and revealed only acute congestion of the lungs on the surfaces of which were a number of irregularly distributed grey patches.

Three days later, further cases of sickness occurred and eventually, out of 35 dogs, all but four became ill. Seven deaths took place, on 17th, 21st, 22nd, 23rd and 25th June, respectively. There was no evidence of the presence of any of the common canine ailments such as distemper, tick fever or *rickettsia*. Feeding of infected meat was discontinued on 22nd June.

A typical case was examined on 24th June, and the account which follows may be taken as characteristic of the disease in general. The dog had been ill for 24 hours when seen and the most striking symptoms were rapid and laboured breathing, with occasional grunting and retching, marked congestion of the visible mucous membranes which took on a bluish-red colour, puffy eye-lids, and soft swellings above the eyes and extending towards the commissures of the lips. The temperature was 104° C., the pulse 200 and the respirations 100 per minute. Auscultation of the chest revealed no evidence of bronchial râles, fluid, congestion or consolidation. There was general malaise and inappetence, and when walking, the animal exhibited a certain stiffness of the hind limbs. Diarrhoea was not a feature. On close examination minute hæmorrhages were observed on the mucous membranes of the buccal cavity.

The course of the disease in fatal cases was rapid, death usually occurring within 12 to 24 hours of symptoms first being observed. In one case heart failure intervened, the patient leaving its bed in response to a summons and after a few steps it collapsed and died immediately.

One detailed post-mortem was performed by the writer, and the most noticeable lesions were as follows: A bluish-red discoloration of the mucous membranes of the buccal cavity, tongue and pharynx; hyperæmia of the mucosa of the stomach; a bile-stained catarrhal inflammation of the small intestine and cæcum; hæmorrhages in the rectum; leucocytic infiltration of the liver; dark, congested kidneys with adherent capsules; hyperæmia of the larynx and trachea; a generally congested and mottled appearance of the lungs with greyish patches irregularly distributed on the surfaces; a dark, soft congested spleen; hæmorrhagic lymph glands; and a congested brain in which tiny hæmorrhages were present.

That horse-sickness can be transmitted experimentally to canines is well established by the work of the late Sir Arnold Theiler, one-time Director of the Onderstepoort Laboratories in South Africa, who, when first studying the behaviour of horse-sickness virus, was able to transmit the disease by serial passage through 49 generations in dogs. Other animals susceptible under experimental conditions are the goat and the mouse. Indeed, the basis of the present horse-sickness vaccine is adaptation of the virus to the brain of the mouse in

which gradual attenuation occurs. Hence the name "neurotropic" vaccine.

The symptoms seen in dogs reminded one forcibly of the classical appearance of horses suffering from the cardiac form of the disease. This is of some interest, for two reasons. In the first place, the horses which were fed to the dogs had died from this form of the disease (Dikkop), and secondly, a study of relevant literature reveals the statement that it is the pulmonary form (Dunkop) that can be transmitted to dogs (Henning, 1949).

Efforts have been made at Kabete to recover the virus from one of the dead dogs by the inoculation of suitable material into horses and mice. No reactions have occurred in the horses, but their susceptibility to horse-sickness was not proved beforehand and it may well be that they were immune. Reactions characteristic of horse-sickness infection have occurred in mice, however, and it is hoped in time to confirm the identity of the virus by appropriate laboratory tests.

This note has been written with the dual purpose of reporting an occurrence of considerable scientific and general interest, and to emphasize the danger of feeding uncooked meat to animals. It is of interest to note that several house-dogs were fed infected meat but only after it had been cooked, and no ill effects occurred.

REFERENCE

Henning, M. W. (1949).—Central News Agency, Ltd., South Africa.

NOTES ON ANIMAL DISEASES

II—EAST COAST FEVER AND RELATED DISEASES*

Compiled by the Department of Veterinary Services, Kenya Colony

EAST COAST FEVER

East Coast fever is a disease of cattle caused by the small protozoan parasite *Theileria parva*. The multiplying stages of this parasite, "Koch's blue bodies", are found in one of the types of white cells (lymphocytes) in the spleen, lymph glands, kidneys and other organs. These stages are occasionally found in the lymphocytes in the blood. The red cells of the blood usually contain other stages of the parasite, known as small piroplasms.

East Coast fever received its name from the fact that the disease was first recognized in cattle introduced into Rhodesia through Beira in 1901.

Methods of Infection.—East Coast fever is non-contagious. In nature the disease is always transmitted by the bites of infective ticks. Experimentally it can be reproduced by the inoculation of spleen pulp and blood taken from an animal reacting to the disease.

Incubation Period.—The incubation period varies from six to twenty-five days, the average period being about thirteen days. The duration of illness is from six to twenty days (usually about eight days) from the first rise in temperature. Under ranching conditions animals may be noticed to be sick only two of three days prior to death. In cases which end fatally death usually occurs from twenty to twenty-five days after exposure to the bites of infected ticks.

Symptoms.—Apart from the rise in temperature, early symptoms are not very marked. The animal may be somewhat listless and tend to lag behind the herd. As the animal continues to feed until the disease is well advanced the illness may pass unnoticed by the native herdsman. The most characteristic symptom is swelling of the lymphatic glands; the superficial glands beneath the ears, in the hollow in front of the shoulder and in the fold of the skin in front of the stifle become prominent. In the later stages oedema of the lungs causes a marked disturbance in respiration. Finally the animal becomes weak, lies down and rises with difficulty or not at all.

Cattle suffering from East Coast fever may relapse to redwater, and in such cases the symptoms of the latter disease are superimposed on those of the former.

In a certain percentage of cases the eyes are affected. A whitish film appears on the surface of the eyeball and blindness results. In cases which recover, the animal regains its sight.

Mortality in adult animals introduced from "clean" areas to highly infected areas may reach 95 per cent. When outbreaks occur in clean areas, however, a high percentage of recoveries is sometimes reported. Such outbreaks may appear so unusual that the true nature of the disease is not suspected. The animals are sick for a few days only, enlargement of the glands is not marked, and may pass unnoticed; in fact, careful examination may reveal that only one superficial gland is slightly swollen. In such cases small piroplasms may be rare in the blood and Koch's bodies may be concentrated in one lymphatic gland. Prolonged searching of a routine gland smear may fail to establish the presence of parasites, although the appearance of the cells in the smear may suggest that the case is one of East Coast fever.

Post-mortem Lesions.—In cases from an enzootic area a diagnosis can often be made from the appearance of the organs after death. It is necessary to stress, however, that in sporadic cases from clean areas the classical lesions are often absent.

In typical cases the lungs are markedly oedematous and hyperæmic. When incised, a frothy, yellowish fluid exudes from the cut surface. Froth may be found in the windpipe and at the nose. When the lungs are thus affected some yellow fluid is usually present in the chest cavity. The heart may show hæmorrhages under the membrane lining the left ventricle.

The fourth stomach is frequently congested and discrete ulcers, usually black in colour and angular in shape, may be present. The intestines may be congested and may show scattered hæmorrhages. Lines of hæmorrhages are often present in the rectum. Lesions in the intestines are often lacking in calves.

The liver is usually enlarged, and mottled and pale in colour. The gall-bladder is usually distended with thick bile. When a breakdown to redwater has occurred the liver is often

* Being a revision of the former article in this series, first published in this Journal, Vol. 12, No. 3, January, 1947.

yellow or orange in colour and, of course, lesions of that disease may be present in other organs.

The spleen may be slightly enlarged, but is not markedly thickened or greatly increased in size unless the case is complicated with redwater.

In typical cases, in adult cattle from highly infected areas, the kidneys show "infarcts", reddish or pale yellowish-white spots varying in size from that of a pinhead to that of a small pea. When near the surface these "infarcts" are seen projecting slightly from the surface of the kidney after the capsule of the kidney has been stripped. Typical "infarcts" are rarely seen in cases from clean areas.

The lymphatic glands are swollen and on section the cut surface is very moist; indeed an excess of fluid usually escapes.

Transmission.—The most important transmitter of East Coast fever is the brown tick, *Rhipicephalus appendiculatus*. The black-pitted tick, *R. simus*, the Cape brown tick, *R. capensis*, *R. Neavei*, and the red-legged tick, *R. evertsi*, were shown experimentally to be capable of transmitting infection during the early years of the century and until recently it was thought that transmission was restricted to species of this genus. In 1937, however, Fotheringham and Lewis showed at Kabete that certain species of *Hyalomma* could also carry infection.

Infection does not pass through the egg of the tick. Larvæ become infected through feeding on an infected animal and after moulting the nymphæ are infective. Similarly nymphæ may pick up infection to transfer to a new animal as adults. If infected nymphæ feed on an immune animal or an insusceptible species, the infection is lost and the moulted adults are clean.

Although a number of different species of ticks are known to be capable of transmitting East Coast fever under laboratory conditions, experience has shown that under natural conditions the brown tick is of far greater importance than the others. About 1911 the Colony of Kenya was divided into the present "clean" and "dirty" areas, and it is now realized that the "clean" areas are, on the whole, areas in which the brown tick does not thrive. Isolated islands where conditions for this tick are more favourable occur in the "clean" areas, and in such islands the control of East Coast fever is always more difficult.

A point of importance in the transmission of East Coast fever is the fact that an infected adult tick can transmit the disease only after it has fed on a beast for a period of not less than 60 hours. An infected tick removed or accidentally detached during the first five days after commencing to feed, should it become attached to another host, is still capable of producing the disease.

Animals Susceptible.—East Coast fever is chiefly a disease of cattle. Sir Arnold Theiler has stated that the Indian buffalo is susceptible and Dr. Lewis at Kabete succeeded in producing a mild infection in an African buffalo.

Non-infected brown ticks fed on the reacting buffalo during the temperature reaction were fed, after moulting, on four cattle non-immune to east coast fever. Three of these cattle contracted east coast fever and died. The disease therefore can be carried by ticks from the African buffalo to cattle, the disease being mild in the buffalo and fatal in cattle.

Beaumont in Kenya also accumulated evidence that eland might carry the disease, infect ticks, and thus pass it on to cattle on farms on which the eland had grazed.

Although game animals may be responsible for some outbreaks of east coast fever it is most likely that they may play a minor role and other causes to account for an outbreak should first be carefully examined.

Immunity.—East Coast fever is almost unique amongst protozoan diseases in that the majority of cattle that recover from one or more natural attacks of the disease develop a durable immunity.

Under experimental conditions a second infection of East Coast fever is likely to occur within a few weeks if the first infection has been mild. Conversely if the first reaction has been severe a second attack rarely occurs within 10 to 15 months and when it does occur it is usually mild and not fatal.

In young calves in enzootic areas complete immunity may not be acquired until after at least two attacks.

The fact that animals born and reared in enzootic areas have a strong immunity, together with the fact that such animals are incapable of infecting ticks, has made possible the use of "T" cattle in Kenya. Cattle from enzootic areas are exposed for six weeks in a heavily infected testing boma. Those that survive are branded "T" or "LT", and such cattle are permitted to move between clean and East Coast fever infected areas.

Treatment.—No substance of plant origin nor any chemical preparation has been found effective in the treatment of east coast fever. The search for a cure is being continued, the vast majority of new chemo-therapeutic preparations being tested in one or other of the veterinary laboratories in Africa.

Preventive Measures.—The only way of controlling East Coast fever is by controlling the transmitting ticks. At one time it appeared as if Mr. J. Walker, O.B.E., late Chief Veterinary Research Officer at Kabete, might have succeeded in elaborating a practical method of provoking an active immunity by the intravenous, subcutaneous and intradermal inoculation of spleen pulp and blood collected from an affected animal. Unfortunately, the method, when tested on a large scale, proved unreliable. A certain percentage of susceptible cattle always failed to react to the injection and later succumbed when exposed to infected ticks. Another variable percentage reacted severely and died. The method, therefore, had to be abandoned.

Fencing, combined with dipping and hand-dressing, is therefore the only satisfactory means of combating the disease available. While dipping and hand-dressing alone can be used to control ticks, fencing renders their application more effective and more complete, and, in addition tends to prevent the introduction of East Coast fever and, of course, the introduction of other infectious diseases.

While fencing necessitates a heavy capital outlay, it is the general experience in Kenya that this outlay is repaid by improvement in the condition of the cattle and in the pasture that results when the cattle are left out all night in paddocks.

Dipping in an arsenical fluid should be combined with thorough hand-dressing of the ears, eyelids, brush of the tail, prepuce of males, etc., parts to which the dipping fluid cannot readily gain access. Hand-dressing is of great importance in the control of East Coast fever, because the brown tick shows a marked preference for feeding in the ears, on the face and in the brush of the tail. Hand-dressing consists of clipping the long hairs and applying by hand either an oily dressing or the usual dipping fluid. One of the most satisfactory dressings is a mixture of one part of 7 per cent nicotine extract and eight parts of crude oil. Old oil from the sump of a motor car may be used.

As the brown tick usually remains on the host for about four days during the larval stage, four to six days during the nymphal stage, and up to eight days during the adult stage, dipping and hand-dressing every three days should theoretically be the ideal method of controlling East Coast fever. In practice, however, dipping every five days in a seven-day-strength dip combined with hand-dressing has proved at least equally effective. In South Africa the latter system is usually employed, although an extra hand-dressing is frequently interpolated in the five-day period.

On farms where previously no measures have been taken to reduce tick infestation it must not be thought that by the rigorous application of control measures a severe outbreak can be checked in a very short time. In practice, even under the best conditions, dipping and hand-dressing will not ensure that every tick is killed before it has fed for 60 hours, and a considerable number of losses may be experienced before the disease is brought under control. On farms where measures to control ticks are in force and tick-life has been reduced to a minimum, outbreaks of East Coast fever can never develop serious proportions. Herein lies the value of cattle cleansing.

Cases of East Coast fever may occur up to fifteen months after the last case. The difficulty that arises in practice is to determine when the last case has occurred. It is recognized that when infecting ticks become scarce cases may be atypical. Such cases have already been mentioned as being not infrequent during the course of outbreaks in clean areas. It is easy to see how such cases, occurring on a farm during the regulation 18-month quarantine period, may go undiagnosed and yet lead to the maintenance of infection in ticks. Failure to diagnose the continuance of infection may also, of course, be due to failure of an owner to submit slides, or to the submission of slides unsuitable for diagnosis; for example, slides from a decomposed carcass.

The advent of synthetic insecticides (DDT, BHC, Toxaphene) opens up wider possibilities in the fight against tick-borne diseases.

In the past the application of universal dipping in African areas has been hindered by the fact that arsenic is too dangerous to use except in tanks. Also it has little residual effect.

Tanks are expensive to build, difficult to site near permanent water supplies and have little application to nomadic tribes. Some of the

newer insecticides, especially benzene hexachloride (BHC, Gammexane) are non-poisonous and can be used as sprays thus overcoming some of the difficulties of dipping. Their residual effect is such that, even though it does not extend beyond the normal 5 to 7 day dipping period, yet this residual killing power plus the greater initial kill will mean that the time taken to cleanse an area will be considerably shortened.

It must be emphasized, however, that dipping tanks will still be needed for the efficient and easy application of the insecticide, and as far as one can foresee the time when tanks can be dispensed with is not yet in sight.

TURNING SICKNESS

In cattle immune to East Coast fever, there occurs on occasion, in certain areas, a condition in which parasites indistinguishable from Koch's blue bodies are found in the brain. This condition is known as "turning sickness" or by its Wakamba name, *Muthioko*.

Occurrence and Etiology.—Turning sickness has only been observed in areas in which East Coast fever infection is very heavy.

All attempts to reproduce this condition experimentally have so far been unsuccessful, and it is not known whether the parasite found in the brain is identical with that of East Coast fever, or whether it is a closely related species. The fact that engorged nymphs, collected at death from a case of turning sickness and fed as adults on a susceptible animal, have on occasion induced an attack of east coast fever suggests that the parasite responsible is *Theileria parva*.

Symptoms.—Symptoms of turning sickness may appear in animals that have recently recovered from East Coast fever or they may develop many years after an animal has passed through an attack of that disease.

The symptoms consist of walking in a circle, either to the right or to the left, or of giddiness. Eventually paralysis usually occurs. Cases may be acute, death occurring within a few days of the animal being noticed sick, or chronic, the animal appearing to recover from the original nervous symptoms but gradually losing condition. In oxen loss of condition is rendered more rapid by working. Chronic cases have been known to live for over a year.

Post-mortem Lesions.—Definite lesions after death are restricted to the brain and its membranes. In acute cases fresh hæmorrhages and clots are found overlying various parts of the brain or in the ventricles. On occasion clots are found in both localities. The blood vessels

of the membranes surrounding the brain are engorged with blood and small hæmorrhages may be discernible in the brain substance.

In chronic cases lesions are not so noticeable. Usually, however, small areas in the brain, that differ from the surrounding tissue by appearing dry or yellowish, may be discoverable.

Diagnosis.—In order to establish a diagnosis of turning sickness, smears are made from the blood clots on the brain or from parts of the brain substance that show hæmorrhages. Such smears should show the presence of Koch's bodies. In this condition it is most unusual to find these bodies in gland or spleen smears. The blood may show the presence of rare small piroplasms.

Treatment.—No method of treating turning sickness has been developed.

SMALL PIROPLASMS

Small piroplasms are one of the commonest parasites observed in the routine examination of blood smears in East Africa. They have already been mentioned as one of the forms of the parasite of East Coast fever. However, a second species of small piroplasm, known as *Theileria mutans*, exists. This parasite, transmitted by the red-legged tick, is rarely of pathological significance. Almost all undipped cattle become infected early in life, and thereafter harbour the organism in a manner analogous to that in which redwater and anaplasmosis are carried. When a carrier animal contracts a serious disease *Theileria mutans* often reappears in numbers in the blood.

The two species of small piroplasms, *Theileria parva* and *T. mutans*, can rarely be distinguished by the microscopical examination of blood smears. During infections with the latter parasite, however, it is unusual to find Koch's bodies in the glands or spleen, hence the necessity for submitting gland or spleen smears for the diagnosis of East Coast fever.

Occasionally when a heavy infection with *Theileria mutans* has also been present, Koch's bodies have been found in the glands of calves dying from paratyphoid. Similarly, when susceptible adult cattle are exposed to a heavy infection with ticks carrying *T. mutans*, a percentage may show Koch's bodies in gland smears during the temperature reaction. All such cases are, however, so rare that the presence of Koch's bodies in gland or spleen smears must be accepted as evidence justifying at least a provisional diagnosis of East Coast fever.

OBSERVATIONS ON THE CHAFER GRUB—A SERIOUS PEST OF WHEAT, MAIZE, FLAX AND OTHER CROPS IN KENYA

By R. Le Peiley, Senior Entomologist, Department of Agriculture, Kenya

(Received for publication on 18th July, 1951)

Very severe damage to maize, wheat, flax and other crops has been caused in recent years by the larvæ of a species of the Melolonthid genus *Schizonycha* in the Trans Nzoia and Uasin Gishu areas of Kenya at altitudes of 5,000 to 7,000 feet. The insect has been examined by specialists and information has been given by the Commonwealth Institute of Entomology that the species is undescribed.

The first definite record of this insect was in 1939 when it was reported attacking maize and flax in the Trans Nzoia, but species of *Schizonycha* were mentioned in the Department's Annual Report for 1912-13 and damage by "White grubs" was also mentioned in the same Report [1]. There is no reason to doubt that the insect is indigenous in the area infested and some damage must have been done from earliest times. Damage to crops was very severe indeed between 1940 and 1946. Since that date the insect has been somewhat less in evidence, and in the last four years populations in general have undoubtedly been lower, yet appreciable damage occurs somewhere in the district every year. During the period 1940-46 the insect is considered to have caused in the Trans Nzoia more damage to cereals and flax than all the other pests of these crops combined.

Owing to shortage of entomological staff, and preoccupation with the control of the Desert Locust, it was not possible to arrange for a full-time investigation of this insect, but the writer made a number of visits to the area and planned a series of experiments to determine the damage to be expected from various population levels, and also control experiments with insecticides, which, with the valued help of other departmental officers, were carried out from 1942 to 1946.

Bionomics, Adult

Information is incomplete, but the main facts of the life history are known. The adult is a fairly small chafer beetle between 14 and 17 mm long and 6 or 7 mm. wide, light brown in colour. It has a one-year life cycle, flying early in the first rains of the year, some time between February and April, usually March. The beetles are present in very large numbers and have been observed to feed on

numbers of herbs, shrubs and trees. The common weed *Bidens pilosa* has been noted as a favourite food and a small indigenous bush of the family Celastraceæ which has not yet been identified was noticed to be the favourite food in grassland and natural veldt in 1943. The beetles often settle in large numbers on wind-break gums and other trees near cultivated land. The following records give dates in connexion with flying:—

March 9th, 1942, Kitale.—Rains broke early in March, about 2 cwt. of beetles were collected in hurricane lamp traps.

February 8th, 1943, Kitale.—Beetles flying following rain.

April 12th, 1943, Kitale.—Few beetles caught in light traps, main flight over.

The normal sex ratio appears to be about 30 per cent females and 70 per cent males. In large collections of beetles the males have always outnumbered the females, and the following are figures of beetles dug from the ground before flying. Beetles obtained, 1,196; females, 340; males, 856. The beetles copulate freely immediately after emerging from the ground for the first time.

After flying the beetles dig into the ground and begin egg-laying. Detailed observations covering the egg-laying period have not been made. There are the usual three larval instars and since egg-laying occurs over a considerable period there is some overlapping of instars, but normally from April till May the first instar is present and from May till July the second instar. From July onwards the third instar is present and it is the grub in this stage that does the real damage. The length of the third instar grub is from 25 to 30 mm. During the crop-growing season while the soil is moist nearly all the grubs present are in the top six inches of soil. The third instar grub is present until about the end of the year, but it begins to go down to pupate in September and in the dry weather in November and December it is normally found deep in the soil. Few observations have been made at this time since the soil is hard and difficult to dig. There may be a resting pre-pupal period, but insects under

observation in the laboratory pupated in January, and from these the first adults emerged at the end of February. Grubs may be found, sometimes in large numbers, in areas of grass and bush that have never been under the plough. The insect is considered to be a normal constituent of the fauna of the natural grasslands of the area.

Laval populations and effect on crops

In the absence of any proved control measures efforts were made to determine the effect of different levels of grub populations in the field, as a guide to the likelihood of success with different crops at different population levels. Owing to the extremely patchy distribution of grubs it is clear, however, that a very large amount of sampling would be necessary before any valuable data on this subject could be compiled. In practice it was even found impossible to plan a satisfactory large-scale control experiment based on sampling in the field, owing to great variations in numbers of grubs in different portions of any area selected. As a result a technique of "planting" a known population of grubs was developed which gave good results in experiments and which will be described in a later section. A large amount of field sampling was done and a general picture of the type of infestation is given by the results, which will be summarized very shortly here. The sampling was done by digging up a square yard of earth to a depth of six to eight inches and collecting the grubs present. Such mechanical methods for sampling as were tried were not satisfactory, though it is not suggested that a mechanical method could not be devised.

An initial survey of part of the Trans Nzoia was made in 1942 to determine the type of infestation present and the following figures were obtained of grubs in square yard samples dug in different crops:—

Maize: 7, 67, 21, 18, 14, 25, 2, 63, 40, 40, 61, 50.

Wheat: 50, 0, 35, 12, 5, 17.

Flax: 27, 13, 30, 25, 31, 19, 15, 1, 14.

Grass: 27, 43, 52, 17, 9.

Sunflower: 35, 22.

Soya beans: 5.

Peas: 3.

Trees: 0.

Bare land: 31.

Weed fallow: 0, 0.

In May, 1943, samples were taken in young maize fields which had been classified as "good" or "poor" on two farms in the main chafer area with the following results:—

Farm (1)—Maize good, chafer grubs per square yard varied from 40 to 0 with an average of 12. Maize poor, chafer grubs per square yard varied from 133 to 0 with an average of 35.

Farm (2)—Maize good, varied from 25 to 0; average 7. Maize poor, varied from 156 to 20; average 81.

In September, 1943, samples were taken in fully grown maize and other crops wherever possible classified as good or poor. At this time it was noted that some grubs had already gone down to pupate and the figures per square yard would undoubtedly have been higher if taken a month earlier.

	No. of sq. yd. sampled	Populations per sq. yd. varied between	Average population per sq. yd.
FARM (3)—			
Maize good	24	13-0	2
poor	18	58-0	6
Sunflower good	6	0-0	0
poor	6	76-0	17
Ploughed land	6	21-0	11
Grass and bush	6	110-36	60
FARM (4)—			
Maize good	25	32-0	9
poor	11	43-1	20
Grass and bush	10	49-9	24
FARM (5)—			
Maize good	8	18-0	3
poor	28	14-0	3
FARM (6)—			
Maize good	16	45-0	8
poor	8	114-24	71
Wheat poor	10	65-0	24
Sunflower good	4	2-0	1

Although there are a host of factors concerned in determining whether a field of maize is good or poor and none of these except chafer grub is considered here, the above results show that in general where there is a higher population of grubs the maize is poorer. That the grubs cause direct damage to maize and other crops is shown in the small plot experiments.

The following observations of an experienced farmer are quoted as indicating the scale of damage that can be caused. They refer to a farm some miles from Kitale and to 1942:—

Maize—300 acres virtually lost, a reduction from normal crop of 10-12 bags per acre to $\frac{1}{2}$ -bag per acre, through chafer grub.

Rye—62 acres—75 per cent loss.

Flax—72 acres—50 per cent loss.

Beans—40 acres—reduction from five to three bags per acre."

Observations by the same farmer:—

"Maize is flattened by wind when grubs are bad. Sunflower is badly attacked, only grows a few feet high, when grubs are bad but if it heads it may be blown down. Rye and wheat, when grubs are bad, fail before 'piping'. Flax may be completely destroyed."

Up to the present the maximum number of grubs observed is 204 large third instar grubs to a square yard.

Small plot experiments to determine the effect of different populations of grubs on crops.

To determine the effect on crops of different populations of grubs in the field would have required such a large accumulation of data as to make it quite impracticable. It was therefore decided to attempt to get an answer to this problem by a small plot technique in which grubs were "planted" with the crops. By this means different (and exact) population levels could be obtained and the results were sufficiently striking to be worthy of record here, both for themselves and also an example of what may be achieved in this sort of investigation by this technique.

The experimental area was carefully dug over so that it was for all practical purposes free from grubs, the grubs were planted with (or shortly after) the crops, to give six population levels, approximately 0; 25,000; 100,000; 200,000; 300,000; 500,000 to the acre, each

population replicated six times on plots of nine square yards in a latin square of 36 plots, with trenches between to prevent movement of grubs from plot to plot. This called for a total of over 36,000 grubs which were obtained by digging in infested land. The following results were obtained:—

FLAX

Grub population per plot	Mean straw weight in lb. per plot
0	5.1
45	4.1
180	3.5
360	2.5
540	1.4
900	0.3

All the data of these experiments were examined statistically by Mr. P. Robinson, Statistician of East African Agriculture and Forestry Research Organization, to whom I am greatly indebted for examining the figures and for his reports herein quoted. The examination showed that a population of 45 grubs per plot (five per square yard): "causes a decrease in yield which does not quite reach the level of probability usually taken as significant, but the difference is so large that there can be little doubt that this difference is real. All other populations cause a highly significant depression in yield".

RYE

Grub population per plot	Mean straw and grain weight per plot	Mean grain weight per plot
0	14.1	3.0
45	13.7	3.0
180	11.6	2.5
360	10.2	2.0
540	9.2	2.1
900	5.0	1.0

The report on the statistical analysis was as follows:—

"Both the grain plus straw and the grain alone give similar results. The least significant difference between the means of six plots is found to be 0.88. It can then be seen that a population of 360 grubs per plot had an appreciable effect."

MAIZE

Grub population per plot	Mean grain weight per plot	Number of plants lying on ground total for 6 plots
0	13.3	8
45	14.2	2
180	12.0	10
360	11.9	7
540	9.0	41
900	8.0	65

Maize is normally planted on the first rains and in this case the maize was already well established when the grubs were planted. Even so, there is a significant reduction in crop at the higher populations. In September the maize was examined for plants blown down, with the results shown in above table. This results from cutting of the main anchoring roots by grubs and this may be so severe as to result in large numbers of fallen plants.

Report on statistical analysis was as follows:—

"The least significant difference between any two of these means is 2.75. In this case therefore the population has to be greater than 360 for an appreciable effect. As regards the fallen plants I think that the figures themselves can be relied on."

This experiment carried out in 1943 was repeated in 1944. The results were not so striking, and this was probably due to the death of larvæ during the process of "planting" which was particularly successfully accomplished the year before. The first year's results are considered a better indication of the effect of the grubs. Results of experiment in 1944 are given in Table I:—

A small experiment with flax and chafer grubs in boxes was carried out. The boxes were potato seed boxes twenty inches square, planted with flax. From 0 to 15 larvæ were placed in each of five boxes. The effect on growth of the plants was indicated by measuring the length of the plants to the nearest three inches in one box of five selected at random. The results obtained are shown in Table II:—

The results show that at the higher populations the majority of the plants were stunted.

As a result of these small plot trials (particularly the first) and many observations in the field, a figure of number of grubs can be suggested at which the chances of a successful

crop are low, though the factors influencing the crop are so many that a sure forecast cannot usually be made as to what will happen in any particular field. In estimating the damage likely in the field from the results of the small plot experiments allowance should be made for the fact that third instar grubs were planted in the plots whereas in the field grubs would have been present feeding in the first and second instars as well, so damage can be expected to be more severe in the field than that caused by a specified number of grubs in the plots.

Flax.—With populations of over 20 grubs to the square yard (about 100,000 to the acre) there is likelihood of severe damage to the crop, and this is borne out by observations in the field. At populations approaching 500,000 to the acre complete failure of the crop has been frequently observed.

Rye.—The experiments were done with rye instead of wheat, since rye grows better at the Experiment Station and it was considered that the effect on wheat and rye would be similar, but this has not definitely been determined. In respect of wire-worm in England it has been stated that rye is often regarded as somewhat more resistant than wheat [2]. It is clear, however, that the effect on crops of wire-worm in England and chafer grub in Kenya may bear no relation since it is stated [2] that linseed and flax are regarded as crops least likely to fail on account of wire-worm damage, while exactly the opposite is the case with chafer grub. With populations of over 40 grubs to the square yard (about 200,000 to the acre) there is likelihood of severe damage to crops of rye. This has been borne out by field observations.

Maize.—With populations of over 60 grubs to the square yard (c. 300,000 to the acre) there is likelihood of severe damage to the crop. This has been observed many times in the field, and many cases of complete or almost complete failure have also been observed at still higher populations, which may in exceptional cases run to 200 to the square yard or more. The following records by a practical and observant farmer are of interest:—

Field 1.—Planted maize March, 1942, sunflower disced in between stooks October, 1942. Maize crop completely destroyed.

Field 2.—Planted maize, 1941, maize completely destroyed. Ploughed in and planted wheat, July, 1941. Wheat partly destroyed, sunflower (green manure) planted in 1942. Maize planted April, 1943, no damage.

Field 3.—Green manure, 1941, maize, 1942, and maize crop partly destroyed, average 60 grubs per square yard. Maize again planted 1943, completely destroyed, average 97 grubs per square yard.

Other Crops.—Insufficient is known about the effect of grubs on other crops to venture any suggestions as to dangerous population levels, but it is certain that severe damage to sunflowers is done by moderate to high populations, and severe damage has also been reported to beans, peas, lupins and even to wattle seedlings.

Is there any practical application to the knowledge of what populations are likely to result in a poor crop? Sampling for chafer grub is a common practice, and the digging of a number of square yard samples in a field gives an idea of the population present. Is this likely to be of use in arranging for allocations of crops to areas of different grub populations? In the case of maize, no, because the crop is planted with the first rains in March or April, when the first flighting period occurs, before the main egg laying. In the case of flax or wheat, which is planted in June or July the sampling in June gives a satisfactory figure of the grub population. But by that time there is no good alternative in the Trans Nzoia to flax, or wheat. It has been suggested that a green manure might be planted, or after ploughing in July planting a quick maturing late wheat, with perhaps a 50/50 chance of a crop, since by September the grubs are beginning to go down to pupate.

Control

Natural Control.—Very little is known about this. There are a number of vertebrate predators of the adults and larvæ, but these do not appreciably influence the population of either. Larvæ have been found (uncommonly) which appeared to have been killed by bacteria, but this cause of death has not been confirmed. Time has not permitted a careful search for local Scoliid parasites and none are known. It seems unlikely that a common indigenous Melolonthid would be without its own Scoliid parasites, but the general impression as a result of digging many thousands of grubs is that the rate of parasitism, if it exists, is very low indeed. The introduction of foreign Scoliid parasites is contemplated.

Light trapping.—Some farmers have used lights to trap beetles during the flighting season. One farmer reported collecting 375 lb. of beetles in one flighting period (approx.

2,000,000 beetles). In view of the well-known fact that with Melolonthid beetles there is usually a great preponderance of males in the insects attracted to light, this was investigated. Of 4,265 beetles caught at light near Kitale on one night (5th March, 1943) 3,999 or 94 per cent were males, 266 or six per cent females. It is clear, therefore, that light trapping is of little economic value.

Cultivation methods.—Beetles are often turned up in numbers with the plough. I quote from a letter dated 29th March, 1943, from a practical farmer who is a keen observer: "I found with with the second ploughing that quite a number of beetles are turned up, some with eggs in them, and quite a number have already laid. I think ploughing being done now is doing a lot of damage to the chafer population." The last sentence is, I think, too optimistic. An experiment to determine whether repeated harrowings had any influence on the infestation of chafer grubs was carried out. Six 5-acre strips were used, two control strips with no discing after the normal preparation of the land, two strips with five discings at three-day intervals, two strips with ten discings at three-day intervals. Sunflower was planted in March and ploughed in early in June. The discings were then given and wheat planted on 24th June, 1943. Damage by chafer grubs occurred but there was less damage on the control strips than anywhere else—the experiment gave no indication of any beneficial effect from the repeated discings. Though it is conceivable that this result might not be repeated *in toto* in another trial, nevertheless, in view of the results obtained, and the cost of discing it is not considered a measure worth taking for chafer control.

Chemical control—Arsenite.—A bait material consisting of coffee buni husk (the husk remaining after removal of the coffee beans from dried coffee berries) and two per cent sodium arsenite, was available and it was thought that this might be eaten by the grubs. A small plot randomized block experiment testing the poison at 200 lb. of bait and 400 lb. of bait per acre and four populations of grubs 0; 100,000; 200,000; and 500,000 per acre was carried out, with no results. A field strip experiment bore this out, showing that this material is useless.

Benzene hexachloride.—A small plot experiment using this chemical was carried out in 1946. The BHC preparation used was an I.C.I. product known as Agrocide 7, containing 20

per cent crude BHC with a gamma isomer content of approximately 2.6 per cent. Two Græco-Latin squares were planted with flax as an indicator plant at 60 gms. of seed per plot of nine square yards, with treatments as follows:—

A. Control. No BHC.

B. 17 gms. per plot of Agrocide 7 (represents approx. 0.5 lb. gamma isomer per acre).

C. 34 gms. per plot of Agrocide 7 (represents 1 lb. gamma isomer per acre).

D. 68 gms. per plot of Agrocide 7 (represents 2 lb. gamma isomer per acre).

To facilitate spreading, the Agrocide was mixed with one cigarette tin each plot of powdered rock phosphate, one tin also being spread on the control plot. Grubs were collected and planted as follows:—

(a) 0.

(b) 180 per plot.

(c) 360 per plot.

(d) 900 per plot.

Table III gives the mean yields obtained in this experiment in pounds of straw per plot.

The report on the statistical examination of the figures is as follows:—

"The least significant difference for the means of eight plots is 1.184. It is then clear that only the highest dose, namely 68 gms. per plot, had any appreciable effect. With the population of 900 grubs per plot the effect was statistically significant."

Strip experiments with BHC

A simple strip experiment was carried out on a farm near Kitale with BHC (Agrocide 7) and rock phosphate at the following rates:—

16 lb. Agrocide 7, plus 64 lb. rock phosphate per acre.

8 lb. Agrocide 7, plus 72 lb. rock phosphate per acre.

4 lb. Agrocide 7, plus 64 lb. rock phosphate per acre.

80 lb. rock phosphate only.

Barley was planted in strips 160 yards long and 12 yards wide using a drill with fertilizer attachment through which the chemical was planted. The chafer grub population at the start averaged 30 to a square yard, but none of the treatments had any appreciable effect on grub populations or on the crop. Another field experiment with BHC in strips was a complete failure as weather conditions were execrable and the oats planted did not come up at all.

Small plot experiment

Thirty-two plots of nine square yards were available for an experiment rather late in the 1946 season. Flax was planted in all plots at the rate of 60 gms. (i.e. 70 lb. seed per acre), grubs were planted in all plots at 1,000 in each plot. Eight treatments were applied each in four plots properly randomized. Results are shown in Table IV:—

Report on the statistical examination of the figures is as follows:—

"The least significant difference is 0.458.

The effect of the BHC becomes appreciable at the dose of 68 gms. per plot."

The effect of heavy dressings of BHC on the soil and on the growth of the plants was considered and in addition to the control plots a plot of 27 feet by nine feet was planted with flax at the same seed rate and treated with 1,632 gms. of 20 per cent BHC, that is equal to the highest rate used in the experiment (representing 16 lb. gamma isomer per acre). In this plot the flax germinated normally and produced a good stand equal to that on untreated soil. This is perhaps surprising in view of the findings elsewhere that BHC is apt to cause a reduction in stand of many crops [3]. Further detailed and careful experiments on this point would be advisable.

A further point may be raised in this connexion. BHC appears both less toxic to plants and less toxic to insects (chafer grubs) than would be expected from results obtained in some other countries. This may be due to a more rapid volatilization in Kenya conditions, and this would seem worthy of study.

The experiments with BHC show that reduction of the grub population can be achieved. They do not give assurance that adequate reduction can be achieved on a field scale at a cost that would make it an economic possibility for cereal farmers in the affected area. However, this does not mean that later developments with different formulations and methods may not prove of economic value. The experiments described herein were carried out with Agrocide 7, because that was available, but this particular BHC preparation was not formulated for the purpose of a soil dressing. There seems promise that methods such as seed dressing with powerful BHC dusts possibly containing a high proportion of the gamma isomer may prove useful. Other toxicants used in this way may also prove of value. The problem of control is difficult but it can be said

that never in the past have prospects been so good that some form of control may be found, now that so many new and powerful insecticides are becoming available.

Little or nothing is known of what soil conditions may favour chafer grub though there is some observational evidence that chafer grub populations tend to be higher the more acid the soil.

The study of the effect of soil conditions should be started by observations in the field on the structure of the soil, organic residues, soil type, past cropping and vigour of crop growth, together with knowledge of the population of chafer grubs. Following this work if some positive correlation appeared to be shown, then a chemical and physical study of the soil would be required.

ACKNOWLEDGMENTS

I owe grateful acknowledgments to a number of colleagues for help with this work. To Mr. R. E. T. Hobbs (then in charge of the Kitale Station on which the experiments were done), for his help and the benefit of his advice throughout, and to Mr. T. L. McClelland for much help in the early stages. I also owe much to two members of the Entomological Section, the late Mr. C. F. Fox and Mr. R. G. Smith for their competent work in the field. It is also

a pleasure to acknowledge much help and valuable information from many farmers.

SUMMARY

1. The paper deals with a species of *Melolonthid*, the larva of which is a severe pest of maize, wheat and other crops in part of the Kenya highlands.

2. The insect has a one-year life cycle, flighting in the early rains about March. The grubs are present from then until about December.

3. Details are given of the effect of different populations on crops. Field observations and small plot observations show that severe damage is likely in flax at over 20 grubs to the square yard, in rye at over 40, and in maize at over 60. In the small plot experiments the grubs were planted in the plots to give a known population level.

4. Experiments showed that BHC was toxic to grubs, with an appreciable effect at 2 lb. of gamma BHC to the acre.

REFERENCES

- [1] Department of Agriculture, Kenya, Annual Report, 1912-13, p. 124, p. 127.
- [2] Wireworms and Newly Ploughed Grassland Agriculture, *Jl. Min. Agric.*, Vol. 50, p. 102.
- [3] Phytotoxicity and off quality of vegetables grown in soil treated with insecticides. Stitt & Evanson. *Jl. Econ. Ent.*, Aug., 1949, p. 614.

TABLE I

Grub population per plot	Mean of flax straw weight per plot	Mean of rye grain weight per plot	Mean of maize grain weight per plot	Sum of fallen maize plants for 6 plots
0	5.9	1.8	18.2	17
45	5.9	1.8	15.7	20
180	5.4	1.9	16.9	12
360	5.0	1.7	13.8	25
540	4.1	1.7	12.0	30
900	2.6	1.3	14.2	49

TABLE II

No. of larvae in box	Total plants present	PERCENTAGE OF TOTAL PLANTS BETWEEN						
		0-3 in.	3-6 in.	6-9 in.	9-12 in.	12-15 in.	15-18 in.	18-21 in.
0	213	—	3	16	33	41	7	—
2	180	—	2	2	10	39	48	—
5	163	1	2	7	27	42	21	1
10	285	1	20	40	31	8	—	—
15	282	1	20	49	29	1	—	—

TABLE III

Population	TREATMENTS				
	A	B	C	D	Mean
(a)	5.20	3.85	6.80	6.35	5.55
(b)	4.25	5.15	4.95	5.25	4.90
(c)	4.05	3.75	5.30	5.45	4.64
(d)	2.20	2.30	2.20	4.30	2.75
Mean	3.93	3.76	4.81	5.34	4.46

TABLE IV

				(1) Gms. Agrocide 7 per plot	(2) Equivalent in lb. gamma isomer per acre	(3) Mean yields in lb. of straw per plot
A	..	..	..	Nil	Nil	1.10
B	..	..	..	8	0.25	1.40
C	..	..	..	17	0.5	1.43
D	..	..	..	34	1	1.43
E	..	..	..	68	2	1.70
F	..	..	..	136	4	1.88
G	..	..	..	272	8	2.10
H	..	..	..	544	16	2.43



FIG. 1—Flax control; no grubs



FIG. 2—Flax; 20 per square yard



FIG. 3—Flax; 60 per square yard



FIG. 4—Flax; 100 per square yard



FIG. 5—Rye control; no grubs



FIG. 6—Rye; 100 per square yard

THE AMOUNT OF MILK CONSUMED BY SUCKLING CALVES FROM BIRTH TO WEANING

By V. A. Eunge and F. Kamya, Animal Health Research Centre, Entebbe, Uganda

(Received for publication on 20th June, 1951)

The foundation stock for the dairy herds on this station was purchased from African cattle owners in Buganda and in the Teso District of the Eastern Province. Most of these cattle had been in milk prior to purchase. The usual method of milking as practised by the African farmer in Uganda is to allow the calf to suckle the dam prior to the commencement of milking, then hand milk as much as possible and afterwards allow the calf to complete the operation by suckling again. Once a cow has been milked in this manner it is almost impossible to milk her without the calf alongside.

In the course of building up a herd, a daughter-dam comparison is desirable to check the progress made. This comparison is difficult if not impossible in cases where the dam is being partially hand milked and has a calf at foot while the daughter is completely milked out and her calf is hand reared. An adjustment is necessary therefore to allow for the milk consumed by the calf.

A trial was commenced on this station in June, 1950, to ascertain the amount of milk consumed by a calf during a lactation.

Three newly calved cows, with calf at foot, were milked during the trial, the details being as follows:—

	Cow No.	Breed	Date of Calving	Lactation
1.	5033	Nganda	13.6.50	5th
2.	81	Zebu	13.6.50	2nd
3.	2526	Zebu	18.6.50	7th

The calves were normal and healthy and were weighed within a few hours of birth, the details are as follows:—

Calf No.	Dam No.	Birth Weight	Sex
462	5033	40 lb.	F.
463	81	40 lb.	F.
465	2526	33 lb	M.

Milking was carried out twice daily at 6.30 a.m. and 6 p.m. and the calves were weighed on a platform scale before and after each feed. If the calf dunged or urinated this

particular weighing was disregarded and an average figure calculated from weighings taken three days before and three days after the event substituted. The calves quickly became accustomed to the weighing and, although a frame around the scale was used in the early stages, they became very adept at balancing on the platform and went on and off as a matter of routine. During the period no sickness occurred neither was any form of treatment given to either cows or calves.

Calf No. 462 suckled for 268 days, calf No. 463 for 274 days and calf No. 465 for 300 days. The milk consumed as calculated by the test weighings is given in Table I.

Table I shows the amount consumed by the calf daily, together with the recorded milk production of the dam and it will be seen that total milk produced by the cow bears no relation to that consumed by the calf.

During the lactation the milk produced by the cows and that consumed by the calves during the morning and evening milking is given in Table II.

The weight at weaning for calves numbered 462, 463 and 465 was 279 lb., 264 lb., and 245 lb. respectively.

The results of this trial show that the three calves consumed by suckling an average of 93 gallons of milk during the lactation. Further trials will have to be undertaken on the amount of milk consumed on average by a calf suckling its dam, but for the purpose of comparing milk production records between a cow hand milked and one milked with a calf at foot, it would appear that a balancing factor of around 90 gallons will be the figure that should be added to the recorded production of the cow suckling its calf. It is emphasized that the object of using this factor where a cow is milked with a calf at foot is purely to provide a basis for comparison of dam/daughter yields to be used in a manner similar to the use of a correction factor for age.

TABLE I

Time in Weeks	Milk Consumed by Calf Daily			Milk Produced by Cow Daily		
	462	463	465	5033	81	2526
	lb.	lb.	lb.	lb.	lb.	lb.
0	6.11	6.00	5.00	7.00	5.53	3.20
4	6.00	5.03	4.93	9.20	6.60	4.29
8	6.39	6.00	4.75	8.80	7.00	5.55
12	3.39	3.61	4.03	8.30	6.80	5.56
16	3.39	2.90	3.00	8.35	5.42	4.74
20	3.25	2.79	3.11	8.93	6.47	4.50
24	2.96	2.18	2.57	8.16	5.80	4.39
28	2.86	3.19	2.71	7.55	4.97	4.55
32	2.39	2.57	2.64	7.68	4.46	3.93
36	2.28	2.14	1.61	5.11	3.38	3.35
40	—	—	1.25	—	—	3.10
43	—	—	1.07	—	—	2.75
Totals	978.75	886.00	950.25	2,192	1,585	1,323

TABLE II

Cow No.	Calf No.	Milk Produced Morning	Milk Consumed Morning	Milk Produced Evening	Milk Consumed Evening
		lb.	lb.	lb.	lb.
5033	462	1,293.25	542.75	898.75	436.00
81	463	907.00	459.50	677.50	426.50
2526	465	762.75	537.00	560.50	413.25
Average		987.66	513.08	712.25	425.25

A NOTE ON THE MEASUREMENT OF RAINFALL INTENSITY

By H. G. Farbrother, Empire Cotton Growing Corporation, Namulonge, Uganda

(Received for publication on 25th June, 1951)

Extensive studies have been conducted in recent years on the effectiveness of rainfall and much valuable information has been accumulated. An aspect of this problem which is of particular importance in the tropics is that of rainfall intensity, and investigations on the high intensity storms characteristic of tropical climates have always been handicapped by the unsuitability or high cost of recording instruments. Estimates of rainfall intensity are of increasing importance with the need for greater production in tropical agriculture, leading on the one hand to pressure on the land with its attendant dangers of soil deterioration and erosion, and on the other to the introduction of mechanization, with increasing exposure to both sun and rain.

The "battering" effect of raindrops on the soil is widely accepted as being one of the more important of the factors involved in the deterioration of soil structure, yet, although it is an obvious effect to the eye, attempts to place tangible values on both cause and effect meet with considerable difficulty. The theoretical aspects, such as mass and terminal velocity of raindrops have been studied by physicists in some detail and on the other hand observational records have been accumulated by soil conservationists, etc., in many countries; but there remains the integration of these two aspects on firstly the experimental plot scale and later on the field scale. In areas where tropical rainstorms are frequent and where a considerable proportion of the annual rainfall occurs as thunderstorms of high intensity the problem is of far more than academic interest. In Uganda, for instance, the two fundamental principles of the grass ley-arable rotation and the development of mechanical cultivation depend to a great extent on the proper understanding of the relation of the characteristics of rainfall with destruction and build-up of soil structure.

A promising and practical line of approach is in the analysis of the intensity of rainfall, and in relating intensity to physical effect on the soil, on a storm by storm basis. The first need then is for accurate determination of rates of rainfall; and this has led to the development of the recorder reported here; the three

premises considered basically necessary in its development were that (a) instantaneous rates must be recorded as such and directly on charts; (b) the time scale must be open enough to enable minute by minute changes in rate to be clearly recorded, and (c) the cost of manufacture must be low as the extremely local nature of thunderstorms make the use of considerable numbers of instruments vital if any reasonable area is to be studied.

TECHNICAL DETAILS

A 22 in. diameter collecting funnel passes the water through a fast flowing cotton-gauze filter (to remove dust, debris, etc.) to an aluminium can (120 size film container) which forms part of a simple spring balance system extended with a pen arm to record depressions on a revolving drum.

The aluminium can has a fine slot cut longitudinally, approximately 1 mm. wide by 50 mm. long, to enable the water to run out. For any particular rate of fall there will be a corresponding point of equilibrium where water running in equals water running out, the section of the area of slot required to pass that quantity will determine the height to which water rises in the can and the corresponding weight of water is recorded on the drum.

Surface tension effects and variations in quantities passed per unit of cross sectional area dependent on head of water in the can result in a non-linear relationship between weight of water in the can and rate of rainfall; calibration curves, however, are prepared which may easily be derived from a series of known rates of flow.

Frequent calibration checks are necessary, not only to detect possible tiring of the balance spring but also to indicate interference from insects, etc. An inverted quart bottle with an attachment on the neck taking a series of small interchangeable tins each with a hole, graded in size to give the desired rates of flow, may be used for this purpose; as the records of these rates are reproduced on the chart in the normal manner, this routine calibration check can be carried out by semi-skilled assistants.

An oil dash pot is incorporated to damp spurious oscillations.

The recording drum is of standard M.O. dimensions, but is driven by a separate clock so as to revolve 24 times per day. The base line drawn on the standard chart thus corresponds with 60 minutes, giving an open scale of approximately $1/5$ th in. per minute. The clock chosen to turn the drum is one of the popular domestic alarm types ('New Dawn' by Smiths English Clocks Ltd., London), in which, owing to the symmetry of the main spring and alarm spindles, it is easy to arrange for twin main springs to give the additional impetus required.

Recorded thunderstorms at the Cotton Research Station, Namulonge, for the two years 1949-50 averaged less than 30 minutes duration for rates exceeding 0.5 in. per hour.

Peak rates were calculated for the period June, 1950, to March, 1951, and are summarized in Table I.

TABLE I

Peak rates in inches per hour of storms from June, 1950, to March, 1951, at the Cotton Research Station.

Range	Frequency	Range	Frequency
0.5-1.49	15	5.5- 6.49	2
1.5-2.49	15	6.5- 7.49	2
2.5-3.49	18	7.5- 8.49	1
3.5-4.49	7	8.5- 9.49	0
4.5-5.49	3	9.5-10.49	1

The working parts of the instrument are illustrated in Fig. 1, and in Figs. 2 and 3 are given reproductions of charts of two characteristic storms.

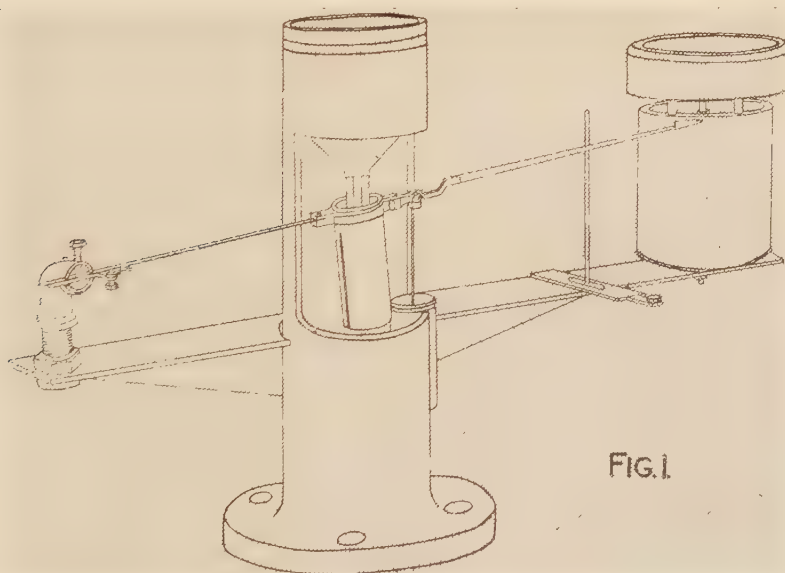
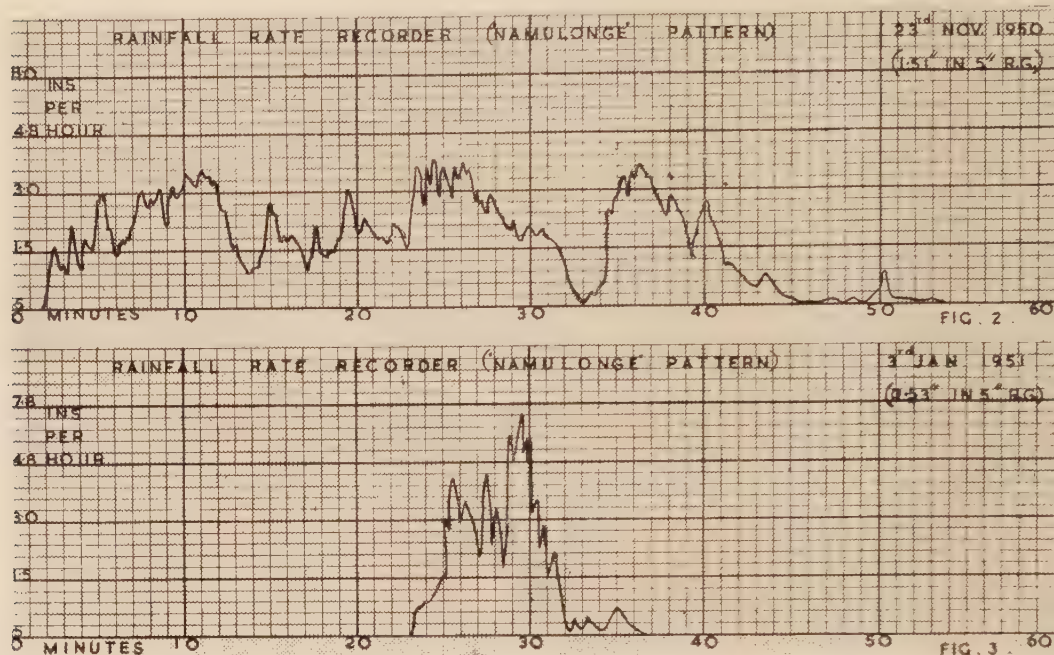


FIG. 1

FIGS. 2 AND 3



FIGS. 2 AND 3

BEEKEEPING OBSERVATIONS IN TANGANYIKA, 1950/51

By Francis G. Smith, Beeswax Officer, Department of Agriculture, Tanganyika

(Received for publication on 8th September, 1951)

Most of these observations were made at Talikwa, some ten miles south of Tabora. The vegetation in this area ranges from semi-hydrosere Mbuga through Miombo Woodland to hill-top *Brachystegia microphylla* with thicket. Here a protective *banda* was built and stocked with Langstroth hives, one of which was kept on platform scales. Scattered about in the trees around were a number of Miombo bark hives, some single chambered and others with a central partition of bark with holes burnt in it. Similar native hives were hung at Tumbi, some ten miles to the west of Tabora. In Tabora itself, one Langstroth hive was sited at the boys' school and another at the girls' school. In the office of the writer a three-frame perspex observation hive was kept occupied for most of the year.

The rainfall of the period was well above average, whereas the rainfall of the previous twelve months had been a little below average.

The early rains began during the last week in October. There was a dry spell from about the 12th to 27th December. During the last week of March and throughout April, very heavy rains were experienced.

The first trees to flower were observed along the edges of the Mbugas at the beginning of September. General flowering occurred from the start of the rain towards the end of October and continued until mid-December. Until mid-April there was occasional flowering of species of minor importance. At the middle of April the first *Isoberlinia globiflora* was seen in flower. The flowering of the *Isoberlinia* continued until mid-June, the trees on the high ground finishing first and those near the Mbugas last. Throughout this *Isoberlinia* period *Pterocarpus chrysotrix* flowered intermittently. After this there were only the herbs and the grasses in flower, and they dried up early in July.

The graph shows the net weight variations of the hive on scales throughout the year. Starting on the 1st August, 1950, in a single Langstroth body the weight was 37 lb. On the 9th it was fed 7½ lb. of 1:1 sugar syrup resulting in a net increase in weight of 3 lb. The remainder of the sugar syrup was dissipated in flying activity. The feeding did however start the queen egg laying. Brood production resulted in a decrease in weight back to 37 lb. At that time the first trees came into flower and after a recovery in weight to 40 lb., daily consumption in brood rearing equalled daily intake. With the start of the rains and the abundant flowering of the *Brachystegia* species, *Combretum*, *Albizia*, *Azelia*, *Burkea*, *Pterocarpus angolensis*, *Terminalia* and other Miombo species at the end of October, the hive weight increased rapidly but erratically to 97½ lb. in mid-December, excluding the weight of the two additional body boxes and frames and foundation that were given. In this early honey flow the net increase over a period of 57 days was 58 lb. Daily increase varied from half-a-pound to 3 lb. During the December dry spell, nectar secretion ceased and the hive weight fell to 95 lb. only to recover again early in January to 100 lb. Inspection of the frames at this time showed that the brood nest had extended into the second body box during the peak of brood rearing. The top (third) box had been hardly touched but the centre box (second) held about 50 lb. of honey with brood on three frames. The bottom box held some honey and most of the brood nest.

From the 12th January onwards there was a steady decline in weight broken by a sharp increase of 4 lb. in three days in mid-February from an unknown source. The decline continued until mid-April when the late and main honey flow commenced. During the inter-flow period brood rearing continued, and the stores in the bottom box were nearly all consumed. The net loss in weight from the 12th January to the 18th April was 19 lb. With the start of the *Isobерlinia* honey flow the weight increased slowly until the end of the heavy rains on the last day of April. The next two days showed an increase of 3 lb. followed by a day's lull. On the 4th May a sudden decrease in weight showed the loss of a 3 lb. swarm. This was followed on the next day by a cast or casts of a total of 5 lb. of bees. On the sixth there was no change in weight. On the seventh the writer inspected the frames, released a mature virgin from its cell and killed the rest of the queen

cells. The hive then settled down to work and despite the loss of 8 lb. of bees increased in weight from 79 lb. on the 6th May to 151 lb. on the 15th June, an increase of 7 lb. in 39 days. This honey flow filled the third body box. From the end of the honey flow until the end of the month daily consumption equalled daily intake. The full third body box was removed on the 27th June and the honey was found to be ripened to a moisture content of 16 per cent (Chataway Hydrometer Tables). From the 1st until the 12th July there was an excess of consumption over intake. Thereafter brood rearing ceased and the weight remained constant at 87 lb.

Over the whole beekeeping year, this hive gave a surplus of 62 lb. of honeycomb which was removed, increased its own stores by 50 lb. as well as sending off 8 lb. of bees in the form of swarms. Had inspection been carried out at the end of April, several days after the *Isobерlinia* flow started, and swarming controlled, the crop would have been very much greater.

From a study of the scale hive several points of management come to mind. The first is that with the Langstroth hive the queen requires two body boxes for her brood nest. If two body boxes have been left on the hive from the previous beekeeping year, then when the honey flow starts early in November, put the empty or nearly empty bottom box on top. This will encourage the bees to store. When it is observed that this upper box is getting full and the bees will be needing more room shortly, give a third box. If the third box contains drawn combs, then a queen excluder can be put under it. If however it contains only foundation do not put the queen excluder under it until the bees have started using the new box. Bees often refuse to go through a queen excluder into a box containing only foundation and then start preparations for swarming as soon as they get cramped for room below. During the honey flow give additional supers as required. Owing to the very strong flavour of *Brachystegia* honey and the difficulty the bees have in ripening honey during the rains, it is best to leave the supers in position when the flow ends in December or January. The next operation is in April, when the *Isobерlinia* flow begins. The brood nest should be inspected for swarm preparations. If the bottom box is found to be nearly empty, as is probable, it should be placed on top, first making sure that the queen is left below the queen excluder. A

week or two after the honey flow is quite finished, the honey crop should be ripe and ready to be removed. That is the proposed form of management with a Langstroth hive.

Many beekeepers prefer to have the brood nest contained in one box only. This makes the task of inspection very much quicker than when two boxes have to be examined. In view of the local bees' tendency to be difficult to handle, anything that simplifies operations is worth considering. It is therefore proposed to use some Modified Dadant hives during the coming year. The Modified Dadant brood box holds 11 frames the same length as the Langstroth but $11\frac{1}{4}$ in. deep instead of the Langstroth $9\frac{1}{8}$ in. This extra $2\frac{1}{8}$ in. in depth of each frame plus the additional frame should provide enough room for the brood nest of any queen. In construction, the Modified Dadant hive is identical to the Langstroth except in dimensions. Using $\frac{7}{8}$ in. timber, the external length of the box is 20 in., as in the case of the Langstroth. The width however is $16\frac{1}{2}$ in. internal, $18\frac{1}{2}$ in. external. The depth is $11\frac{5}{8}$ in. The brood frames are $17\frac{5}{8}$ in. long, $11\frac{1}{2}$ in. deep and the width of the end bars is $1\frac{1}{2}$ in. instead of the Langstroth $1\frac{3}{8}$ in.

With the Modified Dadant hive shallow supers are always used. These supers are the same length and width as the brood box but only $6\frac{3}{8}$ in. deep. It has been found by experience that the most convenient super frame is one having top and bottom bars of the same width, $1\frac{1}{8}$ in., and plain end bars $1\frac{5}{8}$ in. in width. The super holds ten of these frames. The total weight of a full super is 62 lb., of which about 45 lb. is honey. These super frames are figured and described in Mr. R. O. B. Manley's book, "Honey Farming", p. 68, Faber and Faber, (1945).

Supers with this type of frame could also be used with the Langstroth hive. When working mainly for honey production, the frames are wired and fitted with full sheets of foundation. The drawn combs are then used repeatedly, the only wax production being from the cappings. If it is intended to work for beeswax as well, then the shallow frames are not wired and only narrow strips of foundation about 1 in. wide are fastened to the top bar. This starter is to ensure that the bees build the comb in the frames and not across them. When the super is filled and the honey ripened, the combs are cut out leaving a narrow strip along the top bar to act as a starter when the super is given

back to the bees. The cut out comb is then broken up and the honey squeezed out in a honey press. The wax which remains is rendered into clean cakes, ready for sale. Working for beeswax in this manner results in less honey being produced as the bees have to build new comb each time before they can start storing the honey.

During the year a simplification was made in the roofs used. Instead of having a telescopic roof and an inner cover, the two were combined into one simple roof. This simple roof consisted of two $\frac{5}{8}$ in. thick boards side by side and the same length as the length of the body box, 20 in. On top, back and front, were screwed 2 in. $\times$ 1 in. cleats. The two boards were either tongued and grooved together or the joint was covered by a narrow strip of wood. The top of the roof was then given two coats of white paint. These simple roofs have been very successful. They halve the work of opening and closing the hive. The bees secure them with propolis so they do not blow off or let the rain in. I have yet to see how they stand up to Honey Ratel attack.

Observations made on the development of worker brood showed that hatching of the egg took place normally 3 days after laying. Five days later, the eighth day, the cell was sealed. The cell remained sealed for 11 to 12 days. At the end of this period, the nineteenth to twentieth day after egg laying, the young bees emerged. These observations were made in perspex observation hive, areas of brood in different stages of development being marked on the perspex with a wax pencil.

Some information was also obtained on the mating of queens. Two three-frame nuclei, given ripe queen cells from a swarming colony, had the queens mated in one case two days after emergence, and in the other, three days after emergence. Both queens commenced laying two days after mating.

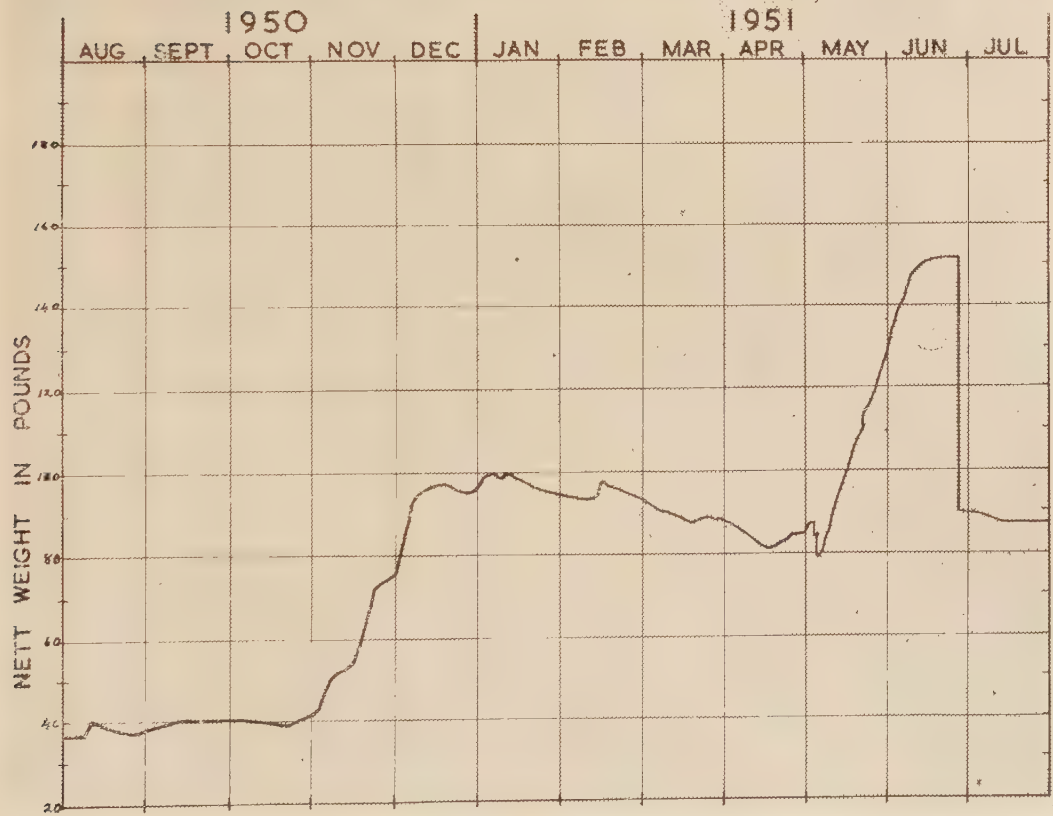
A number of native-type Miomba ba hives were examined at Talikwa and Tum during July, 1950. It was found that those that were occupied during the current season had only sufficient stores to see them through the next season. The combs in such hives were left undisturbed. Those hives which had been occupied since the previous year were in many cases found to have surplus stores. The quantities of surplus beeswax and honey removed from such hives varied between

and 38 pounds. In every case ample stores were left to see the bees through to the next flowering season.

On the whole the beekeeping year 1950-51 has been fair. The rains of the previous year left much to be desired. There was a small amount of swarming at the beginning of the early honey flow. At the beginning of the *Isoberlinia* flow swarms were abundant. As

a result most hives were occupied. It is anticipated that beeswax production in the Miombo woodland areas will be nearly up to average, but honey will be fairly scarce. Abundant nectar secretion usually follows a year of abundant rain. It is possible therefore that the new beekeeping year 1951-52 will be well above average in the production of both honey and beeswax.

SCALE HIVE, TABORA.



A NOTE ON THE RELEASE OF SOME NEW CEREAL VARIETIES—III

By H. C. Thorpe, Department of Agriculture, Kenya Colony

(Received for publication on 23rd August, 1951)

The following six new wheats have been released to farmers from Departmental control for sowing in the 1951-52 season. All have been tested firstly in small trial plots, and then on a field scale in various parts of the Colony, and have been released through normal commercial channels. Fuller details of the procedure were given in an earlier article. [1].

Appearance of a New Physiologic Form of Black Stem Rust

Preparations had already been made for the release of these varieties when a new physiologic form of black stem rust, *Puccinia graminis tritici*, made its appearance. This new rust form was isolated in 1950 both in Kenya and in the Northern Province of Tanganyika; it makes the ninth physiologic form of this rust to be found in East Africa up till the present time. It has been designated K9.

Seedling tests show that two of the new varieties, 360.H and 184.P.2.A.1.A., are resistant to K9 and the remainder susceptible. Since it was considered that these latter varieties were still likely to be of value, and also in view of the need to find a substitute for Equator in the higher wheat growing areas, it was decided to proceed with their release. At the same time farmers were warned, by notice in the local press, of their stem rust susceptibility, as shown in seedling tests, and advised to proceed carefully with these varieties until more is known of their stem rust reactions in the field.

Wheat No. 360.H.

A selection out of the cross 294.M.7.C.6.C. × 184.P.2.A.1.E., bred at Njoro.

360.H is a beardless, white-chaffed, white-grained wheat possessing fair straw strength and medium-length maturity, roughly equal to 294.M, and taking approximately $5\frac{1}{4}$ - $5\frac{1}{2}$ months at Njoro, 7,100 ft. It has full resistance in seedling tests to the nine forms of black stem rust occurring in the Colony, possesses good resistance to orange leaf rust, and has shown resistance to yellow ear rust up to 8,500 ft. in Kenya.

This wheat is similar to 294.M in appearance and straw strength and is slightly superior in yield. It has done well in large scale trials

in the Solai, Subukia, Rongai, Njoro, Ol Kalou, Plateau and Endebess areas of the Colony and should be suited to all areas from 6,000 to 8,500 ft. approximately in Kenya, and 5,500 ft. upwards in the Northern Province of Tanganyika, having a growing season of five to six months' duration.

The grain is of moderate baking quality.

Wheat No. 337.BE.2.F.2.

A selection of the cross 223.F.1.A.3 × 291.J.1.B.1. bred at Njoro.

337 is a beardless, white-chaffed, white-grained wheat possessing good straw strength and quick maturity, taking approximately $5\frac{1}{2}$ months at 8,500 ft. and 6 months at 9,000 ft. in Kenya. It has full resistance to the first eight physiologic forms of black stem rust occurring in the Colony but shows susceptibility in seedling tests to K9. It has been slightly attacked in the field but not damaged. It possesses good resistance to orange leaf rust and has shown resistance to yellow ear rust up to 9,500 ft. in Kenya.

337 has done well in large-scale trials in the Molo-Mau Summit, Ol Kalou, Upper Gilgil and Burnt Forest areas of the Colony and should be suitable to all areas in Kenya from 7,500 ft. to 9,500 ft. having a growing season of five to six months' duration. The variety tends to shed when ripe.

The grain is of poor to moderate baking quality.

Wheat No. 338.AA.1.A.2.

A selection out of the cross 192.Q.2.A.L × Australian 27/2.2.1.5, bred at Njoro.

338 is a beardless, white-chaffed, white-grained wheat of good straw strength. It is of medium-length maturity taking approximately five months at 6,000 ft. in Kenya. It has full resistance in seedling tests to the first eight physiologic forms of black stem rust but shows susceptibility to K9. It has not been attacked by stem rust in the field. It possesses resistance to orange leaf rust and has shown resistance to yellow rust up to 7,000 ft. in Kenya.

338 has done quite well on a field scale in the Machakos and Endebess areas of Kenya and should be suited to all areas of the Colony

from 5,000 ft. to 7,000 ft. having a growing season of five months' duration.

The grain is of good baking quality.

Wheat No. 184.P.2.A.1.A.

A selection out of the cross Reliance $\times$ 286.B6.Y.(L), bred at Njoro.

184 is a bearded, white-chaffed, red-grained wheat. The straw is tall and weakish. It is of medium-length maturity taking approximately $5\frac{1}{2}$ months at 6,500 ft. in Kenya. It has full resistance in seedling tests to all nine physiologic forms of black stem rust, possesses resistance to orange leaf rust and is resistant to yellow rust up to 6,500 ft. in Kenya.

184 has done well on a field scale in the Menengai and Endebess areas of Kenya and should be suited to all areas of the Colony from 5,000 ft. to 6,500 ft. having a growing season of five months' duration.

The grain is of good baking quality.

Wheat No. 350.AD. 9.C.2.

A selection out of the cross 223.F.1.A.3. $\times$ 294.M.7.C.8, bred at Njoro.

350 is a beardless, white-chaffed, white-grained wheat of fair straw strength, and quick maturity taking approximately $5\frac{1}{2}$ months at 8,500 ft. and 6 months at 9,000 ft. in Kenya. It has full resistance to the first eight physiological forms of black stem rust and shows susceptibility to K9 in seedling tests. It possesses resistance to orange leaf rust and is resistant to yellow ear rust up to approximately 8,500 ft. in Kenya.

350 has done well on a field scale in the Molo and Mau Narok areas of Kenya and

should be suited to all areas of the Colony from 7,500 ft. to 9,000 ft. having a growing season of $5\frac{1}{2}$ -6 months' duration. This variety tends to shed when ripe.

The grain is of poor to moderate baking quality.

Wheat No. 341.F.2.D.1.

A selection out of the cross 279.1.5.F.2. $\times$ Eureka G. 2503, bred at Njoro.

341 is a beardless, white-chaffed, white-grained wheat of good straw strength and quick maturity taking approximately six months at 9,000 ft. in Kenya. It has full resistance to the first seven physiologic forms of black stem rust and is susceptible in seedling tests to K8 and K9. 341 has been slightly attacked by stem rust in the field but not damaged. It possesses resistance to orange leaf rust and is resistant to yellow ear rust up to 9,000 ft. in Kenya.

341 has done well on a field scale in the Molo and Mau Narok areas of Kenya and should be suited to all areas of the Colony from 7,500 ft. to 9,000 ft. having a growing season of six months' duration.

The grain is of moderate baking quality.

Note:—

Black stem rust = *Puccinia graminis tritici*.

Orange leaf rust = *Puccinia triticina* (Eriks.).

Yellow ear rust = *Puccinia glumarum* (Eriks. and Henn.).

REFERENCES

- [1] Thorpe, H. C. (1949), "A Note on the Release of Some New Cereal Varieties", *E.A. Agric. J.*, XIV, pp. 210-211.

GRAPHICAL FIELD KEYS OF UGANDA TREES

I—FOREST TREES, MENG0 DISTRICT

By H. C. Dawkins, Forest Department, Uganda

(Received for publication on 29th June, 1951)

INTRODUCTION

This is an experiment in a graphical layout for the preparation of field keys, combined with the use of "spot" characters for rapid identification. It is intended to get over the chief snag of dichotomous and punched-card keys, for both of which the compiler and user need to know a great deal about each specimen; information which for seasonal reasons may be lacking. The present work is designed both as a memory stimulator for those who already know some of the species and as an aid to identification for those new to them.

SCOPE

All species of tree known to occur in the closed forests of Mengo District are included, amounting to about 80 per cent of the total known closed-forest tree flora of Uganda.

With a few exceptions the concept "tree" is that of Eggeing's "Indigenous Trees of Uganda", second edition (in press) revised by Dale. Nomenclature also follows that work.

ARRANGEMENT

Primary breakdown of the key is depicted graphically allowing the entire range of genera to be taken in at a glance, ready classified into groups by well-defined and constantly available characters. The groups, here known as "panels", are then separately treated by alphabetical lists of species with spot characters or short descriptions. Spot characters are selected to be exclusive within the group, so that any italicized feature in the List of Species should apply to one individual in the group only, unless otherwise stated.

This method avoids the tedious retracing of tracks necessary when a wrong turn is taken in a dichotomous key, but of course tends to be cumbersome when more than about 20 species occur in one panel. In such a case, the panel itself could be broken down by a key, but would be much better treated by further subdivisions of the table thus exasperating the printer but extending the advantage of the graphical method.

In the present treatment a single dichotomy has been used in the species lists of panels 8 and 21, but all the others are treated purely alphabetically.

CHARACTERS USED IN THE KEY

The primary characters used are *Leaf Form* and *Leaf Arrangement*. It is thus impossible to place a leafless tree without a branchlet and certainty as to correlation with fallen leaves. It is also virtually impossible to place a very tall specimen without a gun or field-glasses plus careful judgment. Even in this case, however, it will be possible to get some clue from slash colour and exudate.

Secondary characters are concerned with *Exudates*, *Leaf venation* and *Colour of Slash*.

Exudates are simply classified into white or off-white usually opaque *Latex*, and brightly coloured, red, yellow or orange *Resins*. Tea-coloured (Amber) gums and translucent saps are classified with *Exudate Nil* as they grade into the mere wetness common to most cut plant tissues. Exudates should be allowed about 30 seconds to appear.

Leaf venation is used only to differentiate between typically *Penni-nerved* forms where all the lateral veins are of similar size and angle, and the easily recognized *Digi-nerved* forms in which three or more dominant veins radiate from the base of the leaf, resembling a multiple-forked midrib.

In the descriptions, "included" refers to veins more than half immersed in the lamina, while "excluded" indicates those more than half protruding from the lamina.

Colour of slash is divided into two broad classes, those containing any distinct shades of red and those devoid of redness in the white-yellow-brown series. Most red-slashed species do not develop their distinctive colour until over two or three inches stem diameter. When a very small stem reveals no red in the slash it may therefore be necessary to refer to the "Red" panel as well as the white-yellow-brown one to locate its name. (It is also likely that some of the *Rubiaceæ* in Panel 21, never having been seen by the writer over two inches in diameter, may prove to belong to Panel 22.)

The third series of characters used are represented by the following conventions in the panels and in the text:—

INDEX TO CONVENTIONS

BOLD CAPITALS.—Trees capable of reaching "emergent" status, but at least reaching the upper canopy when mature.

ROMAN CAPITALS.—Trees capable of reaching the upper canopy but not commonly exceeding it and usually in its lower layers.

Bold Lower Case.—Trees of the understorey, frequently little more than unusually tall shrubs. They may be canopy trees in very young forest with a total height of 50 feet or less.

Roman Lower Case.—Shrubs and "treelets", included here only to conform with the lower size-limit set by "Indigenous Trees".

† (Dagger).—Armed with thorns, prickles or other sharp processes.

* (Asterisk).—Possessing translucent gland-dots in the leaves, best seen by holding up to the light.

(Stroke).—With a rapidly oxidizing slash, revealed by a darkening or "rusting" of whatever colours are shown by the first cut. Thirtly seconds should be allowed for this feature to appear.

() (Brackets).—Used to indicate a feature that is not constant or well developed, or a species which does not properly belong to the panel in which it is bracketed.

Specific epithets are included in the panels only where a genus has to be split between two panels, or where the species in it differ from each other in potential size-class.

PROCEDURE FOR USE OF THE KEY

1. Determine the position of the leaves and colour of the slash, the latter by a sharp cut on a normal part of the stem with a matchet or knife.
2. Determine the structure of the leaves, together with the nature of their venation and of any exudate that may exist in slash or foliage.
Assign to a panel. Look up the panel number in the List of Species.
3. If the specimen is armed, or has gland-dotted leaves, or has a darkening slash, refer to the appropriately marked names and compare the characters listed with the specimen.
4. If the specimen is undistinguished, run through the italicized spot characters until a relevant one is found. Unless otherwise stated, an italicized character can refer to one species only in the panel.
5. If still unnamed, run through the remaining characters not in italics until a suitable one is found.
6. Last resort—look up the residual likely names in the Tanganyika Check-List (Brenan) or Indigeous Trees (Eggeling), or other suitable Flora.

The comments of anyone who passes this point unsuccessfully are likely to be of interest only to the writer. The only claim made, however, is that field keys on this graphical-cum-spot-character plan will make identification and compilation very much easier than in the past. At the worst, someone new to the local flora will be able to arrive at a group of species from which to select the most likely, instead of having to make exasperating decisions as to anatrophy of non-existent ovules or dehiscence of microscopic anthers.

LIST OF SPECIES WITH DISTINGUISHING FEATURES

(Alphabetically within Panels)

PANEL 1

†*Acanthus pubescens*.—Margins of all green parts including stipules sharp spiny.

†**Aegliopsis eggelingii*.—Gland-dotted leaves with solitary axillary spines, (rare).

Alchornea.—Male flowers in pendulous catkins, female in erect spikes; leaves oblanceolate and crowded to give almost whorled appearance.

A. floribunda.—Leaves 20-50 cm. long with abrupt bases, on petioles less than 5 mm. long.

A. hirtella.—Leaves 10-15 cm. long, petioles 5-20 mm.

Antidesma.—Male and female flowers on long pendulous catkins.

PANEL 1

PANEL 1 (Contd.)

A. laciniatum.—*Stipules conspicuous and much divided into 3-5 acute lobes; 8-12 mm. long.*

A. membranaceum.—*Stipules entire.*

Baphiopsis stuhlmanni.—*Leaves with very distinct venule reticulum included within the lamina below, slender petioles 1-2 cm. long with pulvini at both ends.*

†**Chaetacme aristata.**—*Leaf-apex with sharp needle-like projecting point, margin entire; long woody axillary spines especially on the bole offshoots.*

Cleistanthus polystachyus.—*Elliptical leaves 8-12 cm. long with obtuse bases and long-acuminate apices. Petiole thick, 3-6 mm. long, (rare).*

DRYPETES (three or more species occur, none satisfactorily named).—*Distinctly crenulate or serrate leaf margin, base asymmetrical. Slash yellow clearly layered, turning slowly darker.*

/Ehretia silvatica.—*Slash soft white with brown flecks, turning rapidly dark. Leaves broadly elliptical obtuse based, usually becoming much insect eaten.*

Flueggea virosa.—*Branchlet bases becoming thickened into blunt woody spines on older stems; leaves 2-4 cm. long, broadly elliptical to orbicular.*

Gymnosporia.—*Absolutely glabrous leaves with crenulate or dentate margins and primary veins of irregular form and direction, (rare).*

G. fasciculata.—*Leaves 8-12 cm. long broadly elliptical.*

G. lancifolia.—*Leaves 5-9 cm. long, elliptical.*

HOLOPTELEA GRANDIS.—*Slash hard, of very even texture, yellow, scented as of iodine. Petioles sharply distinguished from the branchlets by their bright green colour where the latter are grey or brown.*

IRVINGIA GABONENSIS.—*Slash strongly scented as of mangoes, densely reticulate, fibrous in lower layers, leaves shiny on both sides, midrib included below, (rare).*

(†)**KLAINEDOXA GABONENSIS.**—*Stipules 5-10 cm. long, slender, visible projecting from the crown and usually abundant on the ground. Buttressed bole often fluted and with branched thorns persistent in the concavities.*

Leptaulus daphnoides.—*Shoot growth by axillary branches, each node bearing a leaf or scar, an axillary shoot growing onwards, and a "main" shoot which aborts or terminates immediately in an inflorescence, (rare).*

Lindackeria mildbraedii.—*Petioles and branchlets densely soft brown hairy, also usually the leaf venation below. Fruits spherical spiny.*

MABA ABYSSINICA.—*Slash bright yellow and conspicuously vertically streaky. (Compare SAPIUM). Bark very dark, bole pole-like.*

MONODORA MYRISTICA.—*Extreme base of leaf lamina where it joins the petiole is minutely auriculate, and turned slightly upwards.*

†**Oncoba spinosa.**—*Leaf crenulate or serrate; straight woody axillary thorns (compare Scolopia). Flowers and fruits solitary in leaf axils.*

Pittosporum ripicola.—*Flowers in massive terminal panicles, seeds red. Slash shining white, scent as of carrot. Leaves 10-16 cm. long, petioles 6-15 mm.*

POLYALTHIA SUAVEOLENS.—*Slash yellow under black rim with golden vertical flecks. Leaves gradually long-acuminate with rounded acumen. Branchlets densely minutely hairy. (Rare, Mabira.)*

Rinorea.—*Ovary (and fruit) distinctly three-lobed but one-celled.*

R. ardisaeiflora.—*Leaves 6-10 cm. long, crenulate and long acuminate, petioles 2-5 mm. long, (rare).*

R. dentata.—*Leaves 9-14 cm. long, crenulate or serrate, long acuminate, petioles 5-25 mm. long, (rare).*

R. illicifolia.—*Leaf margins sharply spinose-dentate, stipules unarmed.*

R. oblongifolia.—*Leaves 12-20 cm. long, entire or weakly crenate, petioles 10-20 mm. long.*

R. poggei.—*Leaves 8-15 cm. long, acuminate with rounded acumen, crenulate to serrate petioles 5-35 mm. long, (rare).*

PANEL 1 (Contd.)

SAPIUM ELLIPTICUM.—*Slash yellow conspicuously vertically streaky (compare MABA), old leaves turn red before falling, usually common on ground. Bole seldom straight.*

(†) **Scolopia rhamniphylla.**—*The white-slashed form is rare, it is usually deep crimson. Leaf crenulate or serrate, flowers numerous in axillary spikes.*

(†) **Tapura fischeri.**—*Minute inflorescences borne at the top of the petiole where it joins the lamina. Foliage delicate, pale, held horizontally, leaves sometimes bearing an inflorescence scar in the place described.*

TETRORCHIDIUM DIDYMOSTEMON.—*Slash copiously exuding amber-coloured (tea) sap.*

UAPACA GUINEENSIS.—*Stilt-rooted, with rounded umbrella-like crown and large long-petiolate leaves. Petioles pulvinate, stipules conspicuous. (Lake-zone.)*

Uvaria.—*Fruits stalked in large clusters 8-15 cm. across.*

U. bukobensis. *Leaves 8-12 cm. long with rounded bases, sub-glaucous below.*

U. welwitschii.—*Leaves 9-13 cm. long, oblong, obtuse at base and apex.*

Uvariopsis sp. nov.—*Very straight growing understorey treelet. Leaves symmetrically elliptical, acute base and apex, lamina at the base folds on to top of petiole to form narrow groove.*

XYLOPIA EMINII.—*Leaves thick and leathery with midrib included below. Broadly elliptical. (Lake-zone, Mabira.)*

PANEL 2

PANEL 2

BARTERIA FISTULOSA.—*Leaves very large, commonly 20-35 cm. long on short petioles. Glandular swellings at stipular positions especially on young shoots.*

(†) **BRIDELIA MICRANTHA.**—*Bole (not branchlets) developing short simple woody spines, usually under 2 cm. long.*

Capparis afzelii.—*Slash with very distinctive bright red layer immediately below the bark, lower part of the slash white.*

* **CASEARIA ENGLERI.**—*Leaves showing distinct comma-shaped gland-dots when held up to the light, especially near the margins and towards the base.*

Erythroxylum fischeri.—*Erect-stemmed regularly branched treelet, with brown bud-scales persistent on the young branchlets. Leaves entire.*

(†) **FICUS (various species).**—*Wide buttressed boles, cork thin or absent over green layer, slash exuding colourless or amber sap, frequently turning darker.*

GELONIUM PROCERUM.—*Leaves densely pale mottled below, (due to raised cuticle in species between venules), (rare).*

(†) **MAGARANGA.**—*Bole beset with branched woody spines, rarely absent. Slash pale brown to red-brown, thin.*

(†) **M. MONANDRA.**—*Leaf margins crenate or rounded dentate.*

(†) **M. PYNAERTII.**—*Leaf margins entire, under surface of leaf scale-speckled.*

MAESOPSIS EMINII.—*Slash red above, yellow below, distinctive scent as of "cold chicken".*

Bark silvery grey with characteristic vertical furrowing.

Ochna, Ouratea.—*Characteristic venation with numerous parallel venules. Conspicuous bright yellow flowers with numerous stamens, sepals persistent in fruit when becoming bright red.*

Oc. afzelii.—*Flowers in unbranched clusters, pedicels about 2 cm. long.*

Oc. bracteosa.—*Flowers solitary axillary, subsessile, (rare).*

Oc. membranacea.—*Inflorescences branched, branches short seldom exceeding 2 cm., (rare).*

Ou. bukobensis.—*Flowers in large panicles, leaves narrow elliptic up to 10 cm., (rare).*

Ou. densiflora.—*Flowers in large panicles, leaves thick, tough, 10-20 cm. long, (rare).*

PANEL 2 (Contd.)

PARINARI EXCELSA.—Leaves conspicuously glaucous beneath (compare *Trichocladus*), veins more than 20 per side of the lamina.

Peddeia fischeri.—Flowers in umbel on naked peduncle solitary in an axil, the tubular green perianth persistent on the fruit as a split brown sheath. Leaves 8-12 cm. long, sessile or with petioles up to 3 mm.

PHYLLANTHUS DISCOIDEUS.—Bark on large stems shaggy fibrous. Slash with many-coloured vertical striations, red, yellow, orange-brown.

(PYCNANTHUS ANGOLENSIS.—*Copious translucent pale reddish sap from slash which is coarsely granular. Leaves glaucous below with conspicuous parallel veins, base cordate. See also panel 6.)*

PYGEUM AFRICANUM.—Slash pink, with distinct almond (cyanide) odour and colourless sap exudate when young. Bark very rough scaling.

†*Scolopia rhamniphylla.*—*Bole thickly beset with very sharp unbranched spines, which start as axillary thorns, slash a striking deep crimson.*

(SPONDIANTHUS PREUSSII var **GLABER.**—*Slash dark red streaky resembling raw meat. Leaves large elliptic on long pulvinate petioles. Usually exuding red resin, see Panel 6.)*

STROMBOSIA SCHEFFLERI.—Obtuse-based broadly elliptical leaves 12-20 cm. long on petioles about 2 cm. long. Venules parallel, at right angles to veins. Slash red, densely streaky with paler shades, (rare).

Thecacoris lucida.—Male flowers in pendulous catkins, females spaced out a few on each pendulous spike. Leaves 6-10 cm. long on petioles up to 6 mm. *Male catkins when young resemble minute sessile cones.*

Trichocladus malosanus.—*Leaves conspicuously glaucous beneath (compare PARINARI) with dark stellate-hair spots, (rare).*

TURRAEA.—(*Flowers with conspicuous staminal tube, from which the long style and swollen stigma protrude.*) Leaves featureless, entire, broadly elliptical.

T. floribunda.—Petioles densely shortly pubescent, staminal tube about 3 cm. long.

/T. **ROBUSTA.**—Slash reddish above, streaky towards wood, *turning rapidly darker and developing a pale bloom on the surface.* Distinct odour as of agarics in slash. Petiole pubescent, staminal tube less than 1 cm. long.

T. vogelii.—Petioles glabrous or puberulous. Staminal tubes about 10-13 mm. long.

TYLOSTEMON UGANDENSIS.—Coarse glabrous leaves on short petioles with very irregular venation, often much damaged, with broadly rounded apices.

/UAPACA **GUINEENSIS.**—*Stilt-rooted with rounded umbrella-like crown, large long petiolate leaves and conspicuous stipules. Petioles pulvinate at both ends.*

WARBURGIA UGANDENSIS.—*Slash (or foliage) with very distinct hot flavour on the tongue. Slash bright red, streaky.*

PANEL 3

PANEL 3

Alangium chinense.—*Slash with thin bright yellow layer immediately beneath the green outer layer. Leaf base very asymmetrical.*

Alchornea cordifolia.—Wide-spreading and confined to forest edge sites. Male and female flowers in pendulous branched dioecious inflorescences.

Alchornea laxiflora.—*Upper side of leaf base where it joins petiole bears a pair of minute thread-like processes.*

CELTIS.—Slashes show dark brown mottling or layering on white or yellow ground (not clear in *C. brownii*).

/C. **brownii.**—Slash pale brown, densely and minutely speckled and turning distinct rusty red.

C. DURANDII var **UGANDENSIS.**—*Slash white with dark brown mottling arranged in vertical streaks or columns, wood chips foul smelling.*

PANEL 3 (Contd.)

- /C. KRAUSSIANA.—*Slash white with dark brown mottling arranged in layers, the white part turning slowly brown.*
- C. SOYAUXII.—*Slash yellow with dark brown layers (compare C. ZENKERI) mature leaves less than 4 cm. wide.*
- C. ZENKERI.—*Slash yellow with dark brown layers (compare C. SOYAUXII) mature leaves usually more than 5 cm. wide.*
- /CORDIA MILLENII.—*Slash pale yellow or off-white turning rapidly through a greenish tinge to dark brown, fibrous-layered, soft.*
- CROTON.—*Characteristic stalked glands at the base of the leaf lamina where it joins the petiole. Slash with strong spicy odour.*
- C. MACROSTACHYS.—*Leaves distinctly cordate at the base, entire, orange or yellow when fallen.*
- C. MEGALOCARPUS.—*Leaves glaucous-white below, bright yellow when fallen, narrow elliptical.*
- C. OXYPETALUS.—*Leaves obtuse to sub-cordate at the base, serrate, (rare).*
†Dovyalis macrocalyx.—*Leaf axils with solitary straight spines.*
- /FICUS (various species).—*Wide-buttressed boles, cork thin or absent over green layer, slash exuding colourless or amber sap, frequently turning darker.*
Grewia pubescens.—*Under surface of leaf softly and shortly dense hairy.*
Ledermannia chrysochlamys.—*All young parts densely clothed in red-brown hairs, (very rare).*
Neoboutonia melleri.—*Large cordate leaves glaucous below due to a dense cover of minute stellate hairs, (rare).*

PANEL 4

PANEL 4

- COLA CORDIFOLIA.—*Leaves large (over 14 cm. long) cordate, not lobed, slightly but distinctly glaucous beneath. Slash coarsely fibrous alternating columns of red and whitish.*
- CROTON MACROSTACHYS.—*Leaves with stalked glands at base of lamina where it joins the petiole. Slash with characteristic spicy smell.*
- Desplatzia lutea.—*Leaves oblong (over 13 cm.) distinctly asymmetrical at the base.*
- DOMBEYA MUKOLE.—*Leaves small (under 13 cm.) cordate-orbicular, slash very soft, fibrous, red. Bark coarsely fissured, soft, thick, pale brown.*
- /FICUS (various species).—*Wide buttressed boles, cork thin or absent over green layer, slash exuding colourless or amber sap, frequently turning darker.*
Glyphaea lateriflora.—*Leaves oblong (under 13 cm.), symmetrical at the base. (Characteristic asymmetrical ribbed pointed fruits 2-5 cm. long.)*
- †MACARANGA.—*Stems beset with woody spines.*
†M. angolensis.—*Leaves lobed, less than 15 cm. long. A spreading forest edge shrub.*
- †M. MONANDRA.—*Leaves not lobed, margins crenate or rounded dentate.*
- †M. PYNAERTII.—*Leaves entire, under-surface scale-speckled.*
- †M. SCHWEINFURTHII.—*Leaves large (over 20 cm.) deeply lobed, petioles often 30-40 cm. long.*
- /STERCULIA DAWEL.—*Leaves large orbicular usually over 13 cm. long, base rounded, rarely sub-cordate. Slash turning rapidly rusty.*
- /TREMA GUINEENSIS.—*Slash very soft, delicate pale pink, slowly turning darker. Very straight growing tree with silvery bark and prominent lenticels.*

PANEL 5

PANEL 5

- Maesa lanceolata.—*Severed petioles and branchlets slowly exude minute droplets of dark red or brown resin.*

PANEL 6

MACARANGA SCHWEINFURTHII.—*Bole beset with woody spines, sluggish opaque red resin from slash. Leaves deeply lobed.*

PYCNANTHUS ANGOLENSIS.—*Copious pale red sap from slash, which is coarsely granular. Leaves glaucous below.*

STAUDTIA KAMEROONENSIS.—*Copious translucent red sap turning dark blood-red. Veins obscure.*

SPONDIANTHUS PREUSSII var **GLABER.**—*Sluggish opaque red resin from slash. Leaves broad-elliptic on long pulvinate petioles. Young leaves shining deep red.*

PANEL 6

PANEL 7

ANTIARIS TOXICARIA.—*Slash smooth creamy-white, exuding creamy often translucent latex (compare MORUS).*

CHLOROPHORA EXCELSA.—*Coarsely granular yellow slash copiously exuding watery latex. Bark very rough, brown to yellowish.*

CHRYSOPHYLLUM.—*Smooth yellow to brown slash slowly exuding white latex droplets from near the wood.*

C. ALBIDUM.—*Leaves over 18 cm. long, elliptical, primary venation clear and distinct from secondary.*

C. NATALENSE.—*Leaves under 18 cm. long, oblanceolate or obovate, apex rounded, glaucous below.*

C. PERPULCHRUM.—*Leaves about 15 cm. long, elliptical, conspicuously red-brown to purple beneath, (very rare).*

Euphorbia teke.—*Thick fleshy leaves, stems with small stipular prickles.*

FICUS (various species).—*Wide buttressed boles, cork thin or absent over green layer, slash and the usually discoloured latex turning rusty.*

MORUS LACTEA.—*Leaves symmetrically three-veined from the base, the veins nearly always showing yellow against the green lamina. Slash smooth creamy white, exuding creamy latex.*

(*Sapium ellipticum.*—*When young has latex droplets in the slash and green parts, see Panel 1, SAPIUM).*

PANEL 7

PANEL 8

SECTION A—LEAVES GLAUCOUS BENEATH

CHRYSOPHYLLUM.—*Slash brown or red-brown never distinctly red.*

C. ALBIDUM.—*Leaves over 18 cm. long, elliptical, primary venation clear and distinct from secondary.*

C. FULVUM.—*Leaves under 14 cm., elliptical, pale brownish beneath. (Lake zone.)*

C. NATALENSE.—*Leaves oblanceolate or obovate with rounded apex, primary veins indistinct and grading into secondary.*

C. PERPULCHRUM.—*Leaves about 15 cm. long, elliptical, conspicuously red-brown to purple beneath (superimposed on glaucous tinge). Primary veins clear and distinct from secondary, (very rare).*

C. SP. NOV.—*Leaves narrow-elliptic, primary veins grading into secondary. (Mabira.)*

MANILKARA DAWEL.—*Leaves silvery shining beneath, usually over 16 cm. long, broadly elliptical, (rare).*

PACHYSTELA.—*Leaves oblanceolate or obovate, distinctly acuminate,*

P. BREVIPES.—*Leaf-bases gradually tapering to petiole, lamina usually less than 15 cm. long. (nb. SERSALISEA has included midrib beneath while in PACHYSTELA it is excluded.)*

P. MSOLO.—*Leaf-bases abruptly sub-auriculate, not tapering gradually into the petiole. Lamina more than 18 cm. long, (very rare).*

PANEL 8

PANEL 8 (Contd.)

SECTION B—LEAVES NOT GLAUCOUS

ANINGERIA ALTISSIMA.—Broadly elliptic leaves less than 10 cm. long, with very distinct primary venation 15-20 per side. Sluggish latex droplets exuded from slash, starting from near wood.

/BOSQUEIA PHOBEROS.—*Copious discoloured latex which turns rapidly rusty red* (compare TRECULIA), leaves less than 10 cm. long, caudate-acuminate.

FICUS (various species).—Wide-buttressed boles, cork thin or absent over green layer, slash and the usually discoloured latex turning rusty.

MIMUSOPS BAGSHAWEL.—Venation obscure, *entirely included in the lamina, very many parallel veins of all sizes joining a distinct single vein parallel with and just inside the leaf margin.*

SERSALISEA EDULIS.—Arcuate veins 8-15 per side, obovate leaves with rounded or obtuse apices, midrib included beneath.

/TRECULIA AFRICANA.—*Copious discoloured latex turning rapidly rusty* (compare BOSQUEIA), leaves usually more than 20 cm. long, *with asymmetrical bases.*

PANEL 9

PANEL 9

(†)**BALANITES WILSONIANA.**—*Leaves bifoliolate, strongly fluted bole often with branched thorns on concavities. Slash markedly reticulate-fibrous near wood.*

†**BALSAMOCITRUS DAWEI.**—*Large spherical hard-walled fruits about 14 cm. usually to be found on ground. Terminal leaflet on long petiolule. Axillary thorns on branchlets. (Mabira.)*

†**Citriopsis schweinfurthii.**—*Leaf rachides broadly winged.*

***Diphasia angolensis.**—Petiole distinctly hairy. (Mabira, rare and poorly known.)

†**ERYTHRINA EXCELSA.**—*Bole armed with conical bosses and the vestiges of thorns, more clearly shown on younger stems.*

Euadenia alimensis.—Bases of lateral leaflets markedly asymmetrical, margins entire.

Ritcheia albersii.—*2-5 foliolate leaves found on the same tree.*

(*)**Teclea.**—Leaves usually thick, tough, gland dots rarely visible.

(*)**T. grandifolia.**—Slash pale yellowish, ribbon-fibrous, petioles semicircular in section, having one flat side.

T. nobilis.—Slash pale greenish to off-white, *rapidly turning through greenish to dark brown.* Petioles circular in section.

PANEL 10

PANEL 10

Allophylus macrobotrys.—Bases of lateral leaflets markedly asymmetrical, margins serrate.

PANEL 11

PANEL 11

ANTROCARYON MICRASTER.—Leaflets eleven or more per leaf *with very numerous parallel veins 25-30 per side. (Very rare, Mabira.)*

Aphania senegalensis.—Very irregular leaves with 2-6 leaflets each, usually 4, (compare PHIALODISCUS). Primary veins grade into secondary.

Bersama abyssinica.—Leaflets regularly opposite, usually sharply serrate distally, glabrous, slash brown.

BLIGHIA WILDEMANIANA.—(Part of year only, *trilocular orange-red fruits with thick fleshy walls.*) Usually four broadly elliptic leaflets per leaf, with well-defined venation but difficult to distinguish from PHIALODISCUS, (rare).

†**Citriopsis schweinfurthii.**—*Leaf rachides broadly winged, gland dots conspicuous.*

***Clausena anisata.**—*Leaflets numerous on each leaf, alternate, asymmetrical, decreasing in size towards leaf apex.*

PANEL 11 (Contd.)

Connarus longistipitatus.—*Terminal leaflet with conspicuous pulvinus on stalk.* (A liane, but under certain conditions and when young, an understorey treelet.)

Craibia brownii.—*Bud-scales and stipules smooth shiny, usually brown, giving axillary buds a characteristic appearance.*

Deinbollia fulvo-tomentella.—*Leaves up to 1 m. long, with many large leaflets densely red-brown hairy beneath.*

†***FAGARA.**—*Curved thorns or prickles on stems and leaf rachides, usually vestigial thorns on bole, mounted on conical bosses.*

†***F. ANGOLENSIS.**—*Symmetrical long-acuminate leaflets, less than 3 cm. wide.*

†***F. MACROPHYLLA.**—*Leaflets very asymmetrical at the base, 4 cm. or more wide.*

†***F. MELANACANTHA.**—*Symmetrical serrate leaflets 3 cm. or more wide.*

†**Harrisonia occidentalis.**—*Leaves with terminal leaflet, less than 15 cm. long, rachides slightly winged. Foliage usually but not always armed with curved prickles.*

MAJIDEA FOSTERI.—*Slash pale yellowish granular with distinctive odour as of thymol (compare ZANHA). Leaflet bases distinctly asymmetrical, rarely less than eight leaflets per leaf. Fruit a dehiscent capsule.*

MILDBRAEDIODENDRON EXCELSUM.—*Leaflets usually more than 25 per leaf, with obtuse to emarginate symmetrical bases.*

MELANODISCUS SP. NOV.—*Basal pair of leaflets rounded and so near the stem as to simulate stipules.*

Pancovia sp.—*3-5 leaflets per leaf on markedly swollen pulvinate petioles, acuminate with rounded acumen. Venation distinct but included beneath the lamina.*

PHIALODISCUS UNIUGATUS.—*Leaves very irregular, often only two leaflets but up to six (compare Aphania). Primary veins distinct in sharp contrast from secondary.*

/POLYSCIAS FULVA.—*Characteristic branching giving appearance of repeated multiple forking without a central vertical leader. Lower part of slash turns greenish.*

ZANHA GOLUNGENSIS.—*Slash pale yellowish granular with distinctive odour as of thymol (compare MAJIDEA). Leaflet bases symmetrical, less than eight per leaf except in saplings.*

PANEL 12

PANEL 12

BAIKIAEA MINOR.—*Leaflets few, usually 2-4, seldom exceeding 6, Venation obscure, minutely reticulate, petioles pulvinate.*

BLIGHIA WILDEMANIANA.—*(Part of year only, trilocular orange-red fruits with thick fleshy walls.) Usually four broadly elliptic leaflets per leaf, with well defined venation.*

CANARIUM SCHWEINFURTHII.—*Pale pink slash with characteristic strong resinous scent (incense), slowly exuding sticky colourless resin.*

CARAPA GRANDIFLORA.—*Leaflets oblong 18-25 cm. long, acuminate, glabrous. (Rare ? not seen by writer.)*

EKEBERGIA SENEGALENSIS.—*Leaflets glaucous beneath usually with a few black spots simulating gland-dots.*

ENTANDROPHRAGMA.—*(Fruits if present, cylindrical 9-18 cm. long opening by curved longitudinal valves.)*

E. ANGOLENSE.—*Crimson-red slash with distinct vertical white or yellowish streaks except when very large. Bark scaling in large irregular flakes.*

/E. CYLINDRICUM.—*Slash pinkish to pale red, strongly scented and turning slowly rusty brown (compare GUAREA).*

PANEL 12 (Contd.)

E. UTILE.—Slash even red, *bole with characteristic regular cylindrical form and regular even-sized fissuring and flaking.* (Mabira.)

/GUAREA CEDRATA.—*Slash pale red strongly scented turning slowly rusty (compare E. CYLINDRICUM).* Leaves with terminal leaflet. Bark scales leave concentric rings of lenticels on bole after falling. *Basal part of petiole (rachis) distinctly winged or at least deeply grooved.*

LANNEA WELWITSCHII.—*Coarsely fibrous red slash* usually with hard granular orange-brown vertical streaks, slightly scented. 5-9 leaflets per leaf with gradually cuneate bases.

LECANIODISCUS VAUGHANII.—Very badly shaped tree with numerous spindly shoots growing up from base of bole. *Slash pale pinkish red.* (East Mabira.)

LOVOA BROWNII.—*Slash even dark red, strongly scented,* 6-10 leaflets per leaf, with symmetrical lamina and straight midrib.

LOVOA SWYNNERTONI.—*Slash red conspicuously layered,* not or slightly scented. Usually more than ten leaflets per leaf, with asymmetrical laminae and curved midribs.

Lychnodiscus cerospermus.—Leaflets serrate extreme-distally only, often weakly so. *Slash yellowish with gritty consistency.*

PHIALODISCUS UNIJUGATUS.—Leaves very irregular, often only two leaflets but up to six. Primary veins distinct in sharp contrast to secondary.

TRICHILIA PRIEURIANA.—*Slash ribbon-fibrous the fibres of alternating shades of pink, yellowish to white.* Bole deeply fluted.

Trichilia rubescens.—*Slash dark red strongly scented* (much resembling **LOVOA BROWNII** in this). Leaf with terminal leaflet, bole deeply fluted.

PANEL 14

PSEUDOSPONDIAS MICROCARPA.—*White to pale red slash slowly exuding minute droplets of scarlet resin.*

PANEL 16

/TRICHILIA.—*Slash produces a few drops of creamy latex from near the wood, which together with the whole slash turns slowly brown.*

/T. SPLENDIDA.—Leaflet apices obtuse or rounded.

/T. SP. NOV.—Leaflet apices acutely acuminate. (Rare, Mabira.)

PANEL 17

ALBIZZIA.—Leaflets usually more than 8 mm. long.

A. EGDELINGII.—*Upper layer of slash with distinct yellowish triangular pattern or fringe on paler ground.* Leaflets on distinct petiolules, apices pointed with points directed forwards; glabrous.

A. FERRUGINEA.—*Leaflet apices rounded, under surface and rachis hairy.* Bark coarsely hairy throughout.

A. GRANDIBRACTEATA.—Leaflets spaced without sides in contact, 3-6 prs. per pinna, with pointed apices directed upwards. Distal pairs much larger than basal pairs of leaflets. *Young shoots and inflorescences with conspicuous stipules.*

A. GUMMIFERA.—Leaflets crowded with the sides in contact, 8-16 prs. per pinna. No stipules, or marked points to leaflets.

(N.B.—There are so many intermediates between the above two species that without the inflorescences it is often impossible to decide to which a specimen tends, much less belongs.)

†**Dichrostachys glomerata.**—Leaflets minute, less than 4 mm. long. *Pods in strong-smelling contorted clusters, persistent on the tree for many months.* Woody spines on stems.

PANEL 17

PANEL 16

PANEL 14

PANEL 17 (Contd.)

PIPTADENIA.—Leaflets about 5-7 mm. long, densely crowded. Bole buttressed.

P. AFRICANA.—Slash yellowish to pale brown, lenticels rarely visible, minute.

P. BUCHANANI.—Slash red-brown except when young, *slowly exuding amber-coloured sticky resin. Lenticels conspicuous, elongated horizontally, labiform when well-developed.*

TETRAPLEURA TETRAPTERA.—Leaflets symmetrical, rounded or indented at base and apex, on distinct petiolules. *Four-winged (lobed) pods usually to be found on ground.*

PANEL 18

†**ACACIA MILDBRAEDII.**—*Bark smooth, shining green, over red slash. Leaflets minute, crowded. (Rare, open swamps.)*

ALBIZZIA CORIARIA.—Leaflets opposite, subsessile, rounded at base and apex, 1-2 cm. long.

ALBIZZIA GRANDIBRACTEATA.—(Usually in Panel 17, but occasionally with red layers in the slash.) Leaflets opposite, pointed and directed forward, subsessile. Distal pairs of leaflets much larger than basal.

ERYTHROPHLEUM GUINEENSE.—Leaflets alternate, exceeding 4 cm. long, distinctly stalked.

PARKIA FILICOIDEA.—Leaflets opposite or nearly so, sessile, auriculate at the base, *curved laterally and with rounded apex, 1-3 cm. long. Wood-chips and seed foul-smelling.*

PIPTADENIA.—Leaflets about 5-7 mm. long, densely crowded. Bole strongly buttressed.

P. AFRICANA.—(Usually in Panel 17, but occasionally slash is pinkish or reddish brown.) Lenticels rarely visible, minute.

P. BUCHANANI.—Slash red-brown, *slowly exuding amber-coloured sticky resin. Lenticels conspicuous, elongated horizontally, labiform when well-formed.*

TETRAPLEURA TETRAPTERA.—Leaflets symmetrical, rounded or indented at base and apex, on distinct petiolules. *Four-winged (lobed) pods persistent, usually to be found on ground.*

PANEL 19

PANEL 19

/Schefflera urostachya (usually a liane but sometimes almost of tree form). Leaflets on long petiolules 2-8 cm. long, glabrous.

/Myrianthus arboreus.—Leaflets very large, greyish, usually over 20 cm. long. Bark smooth, silvery.

Rircheia albersii.—Leaflets entire, less than 10 cm. long, usually with 3-5 foliolate leaves on the same tree, (rare).

PANEL 20

PANEL 20

MUSANGA CECROPIOIDES.—*Leaflets 12-16 on one leaf. Stipules very large, usually to be found on ground, with silvery hairs on inner side simulating fur.*

/Myrianthus arboreus.—*Leaflets 5-7 per leaf.*

PANEL 21

PANEL 21

SECTION A—WITH INTRA-PETIOLAR STIPULES

(The Rubiaceae or Rhizophoraceae)

Belonophora glomerata.—Large (over 12 cm. long) leaves, glabrous, with axillary clusters of sessile flowers, (rare).

Bertia.—Large (over 12 cm. long) glabrous leaves.

B. capitata.—Flowers in compact globular terminal heads, (rare).

B. racemosa.—Flowers in leafless terminal spikes bearing separate flower clusters, (rare).

Canthium vulgare.—Leaves small (less than 12 cm. long) flowers in axillary many-flowered cymes.

PANEL 21 (Contd.)

Cassipourea ruwensoriense.—*Branchlets and under-surface of leaflets densely brown hairy.* Leaves less than 12 cm. long.

Coffee.—Axillary clusters of sub-sessile flowers.

C. canephora.—Leaves over 12 cm. long, flower clusters usually containing more than five flowers, (rare).

C. eugenioides.—Leaves less than 8 cm. long, flower clusters with less than five flowers.

Craterispermum laurinum.—Leaves less than 12 cm., glabrous with *characteristic conspicuous vein reticulum* included within the lamina. Flowers in supra-axillary short stalked clusters.

MORINDA LUCIDA.—*Bright yellow slash with distinct purple shades in the cork* which sometimes extend deeper. Flowers borne on spherical stalked green heads.

Oxyanthus.—*Corolla tubes very long (6-10 cm.) and slender (2-5 mm. diam.).* Flowers borne in short axillary racemes one per node.

O. speciosus.—Glabrous leaves 10-18 cm. long.

O. unilocularis.—*Hairy leaves 20-30 cm. long,* frequently much damaged by insects.

Pamphlethantha viridiflora.—Narrowly elliptic or oblong leaves 10-14 cm. long with prominent arcuate venation 12-18 veins per side. Foliage bright green.

Pavetta insignis.—Leaves over 15 cms. long, glabrous flowers numerous in terminal umbel-like racemes.

Randia.—*Shoot growth peculiar,* at each node the central shoot terminates in a single flower and or leaf, while one or both axillary shoots grow on to form leaders.

R. urcelliformis.—Leaves 6-10 cm. long.

R. malleifera.—Leaves 12-20 cm. long, (very rare).

Vangueria apiculata.—Leaves less than 12 cm., flowers in short axillary racemes, calyx lobes narrow elongated.

SECTION B—WITHOUT INTRA-PETIOLAR STIPULES

(Families other than Rubiaceae)

ANTHOCLEISTA SCHWEINFURTHII.—*Leaves very large 20-50 cm. long, obovate, glabrous, gradually tapered to the base.*

Eugenia bukobensis.—*Lateral veins run direct to a distinct intra-marginal vein parallel and close to the margin.*

LINOCIERA JOHNSTONII.—*Petioles thick, grey-scaly,* usually 1-2 cm. long, leaves 12-18 cm.

Memecylon myrianthum.—*Leaves shiny glaucous below with very indistinct venation.*

SCHREBERA MACRANTHA.—Leaves broadly elliptic 7-9 cm. long, with obtuse or rounded-acuminate apex, on petioles 15-30 mm. *Fruits characteristic, obconical, hard woody,* usually to be found on ground.

†**Scutia myrtina.**—*Leaves subopposite (not exactly opposite) with small axillary curved prickles.*

STEGANTHUS WELWITSCHII.—Leaves narrow-elliptic 8-12 cm. long, with gradually acute-acuminate apex. Leaf slightly glaucous beneath. (Young shade leaves very similar to those of LINOCIERA but without scaly petiole).

STRYCHNOS MITIS.—*Leaves with prominent asymmetrical pair of arcuate veins arising 5-10 mm. up the midrib from the base of the lamina.*

(VOACANGA OBTUSA. Petiole-bases with cup-like stipular appendages, leaves, but not old tree slash, with latex.)

PANEL 22

Dictyandra arborescens.—Calyx-lobes large contorted, appearing like leafy appendages to the flowers and persistent in fruit. Leaf base gradually tapering. (Rubiaceae, with intra-petiolar stipules.)

ELAEODENDRON BUCHANANI.—*Slash deep crimson with conspicuous bright orange inner surface to the cork.* Leaf margin crenate, vein reticulum coarse and irregular.

Lasiodiscus mildbraedii.—*Secondary veins forming a distinct parallel reticulum at right angles to the primary veins.* Leaf margin crenulate.

MITRAGYNA.—*Large orbicular leaves 10-20 cm. wide.* (Rubiaceae, with intra-petiolar stipules.)

M. RUBROSTIPULATA.—Stipules with 6-10 veins branching to form a definite reticulum, hairy.

M. STIPULOSA.—Stipules with 10-20 veins, reticulum obscure, glabrous.

MORINDA LUCIDA.—*Slash bright yellow at least near the wood, but often tinged with reddish or purple in outer parts.* Flowers borne on spherical stalked green heads. (Rubiaceae, with intra-petiolar stipules.)

SYZYGIUM GUINEENSE.—*Lateral veins numerous (5-10 per cm.) all passing straight to a vein parallel with and near to the leaf margin.* Slash even brown.

PANEL 23

Mallotus oppositifolius.—Leaves on long petioles 2-5 cm. long, leaf-bases obtuse or cordate.

MEMECYLON JASMINOIDES.—Leaves shortly petiolate or sessile, *strongly and symmetrically three-veined from the base.*

STRYCHNOS MITIS.—Leaves shortly petiolate, weakly three-veined from the base, *a stronger asymmetrical pair of arcuate veins arising 5-10 mm. up the midrib from the base of the lamina.*

PANEL 25

GARCINIA BUCHANANI.—*Slash exuding bright yellow resin* (compare **SYMPHONIA**), leaves without intra-marginal vein, primary veins bending arcuately towards leaf apex.

SYMPHONIA GLOBULIFERA.—*Slash exuding bright yellow resin,* (compare **GARCINIA**) lateral veins passing straight into a distinct intra-marginal vein.

PANEL 26

Harungana madagascariensis.—*Slash pink exuding bright orange resin.*

PANEL 27

Conopharyngia.—*Petiole bases with cup-like stipular appendages* (compare **VOACANGA**). Leaf apices pointed.

C. holstii.—Leaves large broadly elliptic, more than 8 cms. broad, margins entire.

C. usambarensis.—Leaves narrow elliptic to oblong, less than 8 cm. broad, margins undulate, (rare).

FUNTUMIA.—Straight-growing trees with cylindrical boles.

F. ELASTICA.—*Latex coagulating to form a dry rubber between the fingers.*

F. LATIFOLIA.—Latex becoming and remaining sticky gum-like between the fingers.

PICRALIMA NITIDA.—*Leaves with distinct intra-marginal vein,* devoid of cupulate petiole-bases.

Pleiocarpa pycnantha.—*Leaves frequently in threes, 6-10 cm. long including the petioles.* Apices sharply pointed.

VOACANGA OBTUSA.—*Petiole-bases with cup-like stipular appendages* (compare **Conopharyngia**). Leaf apices rounded devoid of point or acumen.

PANEL 22

PANEL 23

PANEL 24

PANEL 26

PANEL 27

PANEL 28

PANEL 28

(*Mitragyna rubrostipulata* (see Panel 22) when young has a milky latex in the growing points and very young leaves.)

PANEL 31

PANEL 31

***/FAGAROPSIS ANGOLENSIS.**—*Leaf margins with a single row of gland-dots*, one in each indentation of the crenulate margin. Slash highly distinctive; cork with orange under-surface, upper layer of slash grey with orange spots in upper part persistent from the cork, lower part of slash white turning dark.

/KIGELIA MOOSA.—*Slash thick, off-white with grey-brown blotches, very soft.* Leaves glabrous.

/MARKHAMIA PLATYCALYX.—*Slash thin, off-white, fibrous. Yellow corollas* often to be found on ground.

/SPATHODEA CAMPANULATA.—*Foliage and branchlets hairy, fruit-pods boat-shaped*, usually to be found on ground.

PANEL 39

PANEL 39

VITEX.—*Leaflet petiolules less than 2 cm. long, hairy.*

V. AMBONIENSIS.—*Leaflets broader towards the apex.*

V. FISCHERI.—*Leaflets regularly symmetrical.*

PANEL 41

PANEL 41

/PREMNA ANGOLENSIS.—*Leaves on long petioles 3-6 cm. long.*

(*RAUVOLFIA*, included here because some mature parts do not have the latex always to be found in young parts, see Panel 44.)

PANEL 44

PANEL 44

ALSTONIA BOONEL.—*Veins pass straight to a distinct intra-marginal vein very near the leaf margin.* Leaves glaucous beneath.

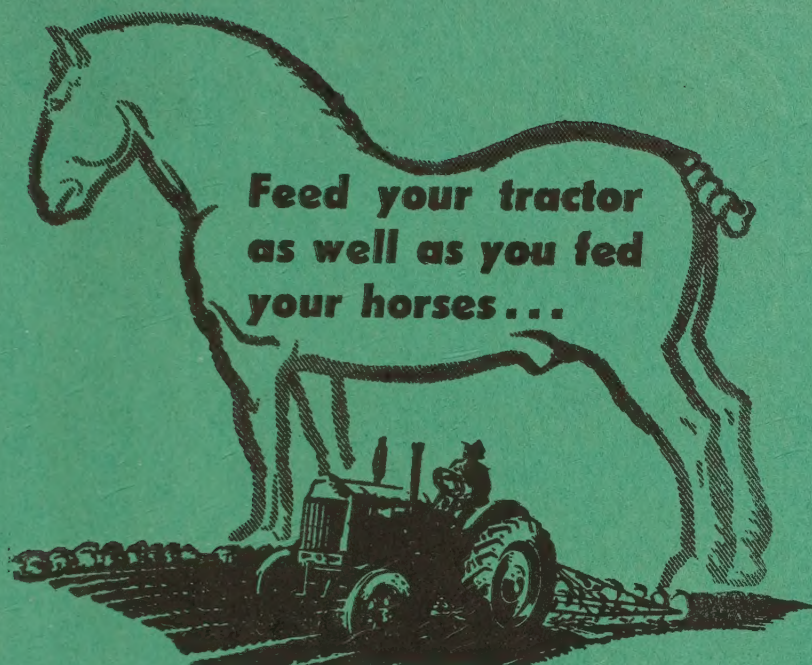
Pleiocarpa pycnantha.—*Leaves in threes*, but often with some nodes carrying only two. (See Panel 27.)

RAUVOLFIA.—*Veins arcuately directed forwards*, mature slash without latex.

R. OXYPHYLLA.—*Leaves 10-20 cm. long including the petioles, distinctly glaucous* beneath.

R. vomitoria.—*Leaves 7-12 cm. long, not glaucous beneath.*

			LEAVES ALTERNATE			LEAVES ALTERNATE			LEAVES OPPOSITE			LEAVES WHORLED									
			Slash White, Yellow, Brown			Slash Red			Slash White, Yellow, Brown			Slash Red									
LEAVES SIMPLE	Exudate Nil or Colourless	Leaves Pinninerved	1	†Acanthus †*Aegliopsis Alchornea Antidesma †Chaetacme Cleistanthus /DRYPETES Ehretia Flueggea Gymnosporia HOLOPTELEA IRVINGIA	(†)KLAINEDOXA Leptaulus Lindackeria MABA MONODORA †Oncoba Pittosporum POLYALTHIA Rinorea SAPIUM (†Scolopia)	/Tapura TETRORCHIDIUM /UAPACA Uvaria Uvariopsis XYLOPIA	1	2	BARTERIA †BRIDELIA Capparis *CASEARIA Erythroxylum /FICUS GELONIUM †MACARANGA †MONANDRA †PYNAERTII MAESOPSIS Ochna afzelii bracteosa membranacea	2	2	Ouratea PARINARI Peddeia PHYLLANTHUS PYGEUM †Scolopia STROMBOSIA †MACARANGA Thecacoris Trichocladus TURRAEA floribunda /ROBUSTA Vogelii	2	21	ANTHOCLEISTA Belonophota Bertiera Canthium Cassipourea Coffea Craterispermum Eugenia /LINOCIERA Memecylon myrianthum MORINDA Oxyanthus	21	22	Dictyandra ELAEODENDRON Lasiodiscus MITRAGYNA MORINDA SYZYGIIUM	41	41	/PREMNA (RAUVOLFIA)
		Digi-Nerved	3	CELTIS /brownii DURANDII /KRAUSSIANA SOYAUXII ZENKERI	Alangium Alchornea CROTON MACROSTACHYS MEGALOCARPUS OXYPETALUS	/CORDIA †Dovyalis /FICUS Grewia Ledermannia Neoboutonia	3	4	CROTON MACROSTACHYS COLA Desplatzia DOMBEYA /FICUS	4	4	†MACARANGA †Angolensis †MONANDRA †PYNAERTII †SCHWEINFURTHII Glyphaea	4	23	Mallotus MEMECYLON JASMINOIDES STRYCHNOS	23					
	Latex	Coloured Resin	5	Maesa			5	6	†MACARANGA SCHWEINFURTHII	6	6	PYCNANTHUS STAUDTIA SPONDIANTHUS	6	25	GARCINIA SYMPHONIA	25	26	Harungana			
			7	ANTIARIS CHRYSOPHYLLUM ALBIDUM NATALENSE PERPULCHRUM	CHLOROPHORA Euphorbia /FICUS MORUS (Sapium)		7	8	CHRYSOPHYLLUM ALBIDUM FULVUM NATALENSE PERPULCHRUM SP.NOV.	8	8	ANINGERIA /BOSQUEIA /FICUS MANILKARA MIMUSOPS	8	27	Conopharyngia FUNTUMIA PICRALIMA Peliocarpa VOACANGA	27	28	(Mitragyna) (rubrostipulata)	44	44	ALSTONIA Pleiocarpa RAUVOLFIA
Leaves Tri-Foliolate or Bi-Foliolate			9	(†)BALANITES †*BALSAMOCITRUS †*Citriopsis	*Diphasia †ERYTHRINA Euadenia	Ritcheia (*)Teclea	9	10	Allophylus	10	10		10								
LEAVES PINNATE	Exudate Nil or Colourless		11	ANTROCARYON Aphania Bersama BLIGHIA †*Citriopsis *Clausena Connarus Craibia	Deinbollia †*FAGARA †*ANGOLENSIS †*MACROPHYLLA †*MELANACANTHA †Harrisonia MAJIDEA MILDBRAEDIODENDRON MELANODISCUS	Pancovia PHIALODISCUS /POLYSCIAS ZANHA	11	12	BAIKIAEA BLIGHIA CANARIUM CARAPA EKEBERGIA (/)ENTANDROPHRAGMA /GUAREA LANNEA	12	12	LECANIODISCUS LOVOA Lychnodiscus PHIALODISCUS TRICHILIA PRIEURIANA rubescens	12	31	*/FAGAROPSIS /KIGELIA /MARKHAMIA /SPATHODEA	31					
		Red Resin					14	14	PSEUDOSPONDIAS	14	14										
	Latex							16	16	TRICHILIA SPLENDIDA SP. NOV.	16	16									
Leaves Bi-Pinnate			17	ALBIZZIA EGGELINGII FERRUGINEA GRANDIBRACTEATA GUMMIFERA	†Dichrostachys PIPTADENIA TETRAPLEURA		17	18	†ACACIA ALBIZZIA CORIARIA GRANDIBRACTEATA	18	18	ERYTHROPHLEUM PARKIA PIPTADENIA TETRAPLEURA	18								
Digitate			19	/Schefflera	/Myrianthus	Ritcheia	19	20	MUSANGA	20	20	/Myrianthus	20	39	VITEX	39					



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